GEOTECHNICAL INVESTIGATIONS REPORT OF THE PIPING FAILURE OF ANITA DAM

First Phase of Additional Investigations (Site Inspection, Test Pitting, and Laboratory Testing)

Report by Lovell Parish

Purpose of this Report

The purpose of this report is to document the results of the first phase of additional geotechnical investigations of the piping failure of Anita Dam. This program is part of a cooperative effort by personnel from the Bureau of Land Management (BLM), Bureau of Reclamation (Reclamation), and the State of Montana to determine the cause of the dam failure and conclude if the structure can be safely and economically reconstructed. This portion of the post-failure explorations was the first of two phases of additional investigations recommended by the Board of Inquiry convened to investigate the failure. It included a comprehensive site inspection, in situ testing, test pitting, and extensive laboratory analysis of embankment and borrow area materials. Goals were to help determine the initial route or routes of failure through which the piping progressed, and evaluate the embankment and borrow area materials to determine if their characteristics were either factors in developing the piping path or in accelerating the rate of erosion.

A bibliography and other pertinent background data used in preparing this report are included in attached Appendices A through I.

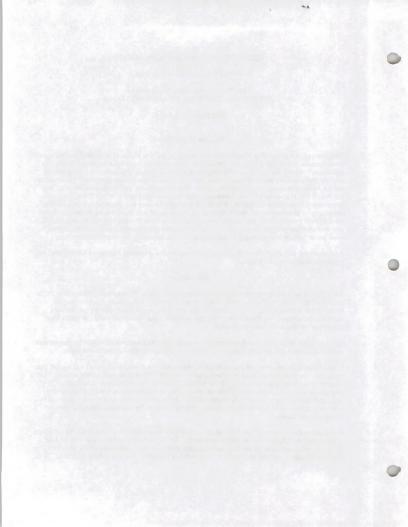
Site Geology

Anita Dam is located in the glaciated portion of the Great Plains Physiographic Province in northcentral Montana about 22 miles north of the town of Chinook. The area is characterized by nearly flat to slightly rolling, grass-covered plains with the topography broken by two isolated mountainous areas. The Sweetgrass Hills rise about 90 miles to the west and the Bears Paw Mountains lie about 40 miles to the south.

Local geologic units consist of the upper Cretaceous age Bearpaw Shale overlain by Pleistocene glacial sediments and Recent alluvium and colluvium along the creek channel and walls.

Subsurface explorations at the dam site did not encounter the shale bedrock and it does not crop out within the reservoir or along the creek channel immediately downstream from the dam. The deepest drill holes penetrated to depths of 99 feet below the ground surface. Literature references describe the Bearpaw Shale as a dark gray to brownish-gray marine shale or clay shale containing iron-rich concretions and thick bentonite beds. When weathered, it forms the notorious gumbo soils that can be so treacherous for wet weather travelers along the Missoun Breaks farther south.

Immediately overlying the shale bedrock are glacial sediments consisting primarily of till units with minor zones of outwash and lacustrine sediments. The till is mostly composed of clay and silt fines with minor amounts of sand, gravel, cobbles, and a few boulders. Laboratory tests indicate that the local till is somewhat finer than the typical tills both east and west of the dam site. Till at



the dam site is composed of about 75% clay and silt fines, 20% predominantly fine sand, and 5% mostly fine to medium gravel. Cobbles and small boulders only constitute a trace in the local material. The brownish-gray, weathered tills near the ground surface usually classify as CL in the Unified Soil Classification System, and grade to CL-CH or CH in the dark gray, unoxidized tills encountered at depth. Gypsum granules and crystals are common, especially in the top few feet of the till and along scattered joints, but constitute only a tiny percentage of the total mass. By far the majority of material encountered by investigations at Anita Dam was till. It is usually considered a slowly permeable to impermeable material and is commonly used for compacted embankment construction in claciated areas.

Outwash zones within the till are usually discontinuous with a very limited extent except in the rare occurrences of buried pre-glacial river channels. Composition of the outwash material can be quite variable, but usually consists of relatively clean, pervious mixtures of sand and gravel. The materials often contain limited amounts of trapped water and may even be of importance as local aquifers if the units are of adequate size. These units can be a route for seepage past engineering structures and must be carefully defined at each site. Only a very small amount of outwash material was encountered in investigations at the dam site.

Glacial lake and pond sediments are frequently interbedded within the till units. They are usually composed of thinly bedded or varved clay, silt, and very fine sand units. The material is slowly permeable to impermeable, but the fine nature of the sediments and resultant poor workability most often preclude their use for impervious fill. Some of these units were encountered in the borrow areas east of the structure, and if they are to be used as compacted embankment, should be carefully mixed with the surrounding till.

Alluvial sediments occur along the creek channel passing through the dam site. They are highly variable in composition and may be intermixed with local colluvial materials washed from the valley walls. Excavations in the core trench for the dam encountered these materials and the depth of the cutoff was increased to insure that the more pervious layers of dirty sand and gravel were removed from the excavation and did not extend beneath the structure.

Findings

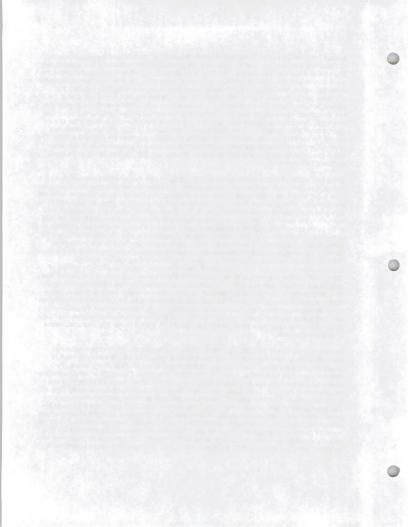
An initial site examination by members of the Board of Inquiry did not end in a conclusive answer as to the cause of the piping failure (Photographs 1 and 2). Recommendations by the Board for the first phase of additional investigations included excavating and inspecting the right upstream end of the outlet pipe where fill remained in contact with the structure to see if any knowledge could be gained about the route of initial failure, conducting Trober densities and moistures of the remaining construction materials, and collecting embankment samples from the vicinity of the outlet pipe for further testing. Those recommendations were completed on April 10, 1997. Other activities carried out at the same time included photography of the interior of the outlet pipe using a still camera; resurveying of elevations across the crest of the dam and tops of appurtenant structures; inspection of both emergency spillways; inspection of the downstream outlet channel; inspection of the reservoir floor for sinkholes; inspection of the riprap; and excavation and collection of materials samples from 3 test pits in a potential borrow source immediately east of the construction borrow area, and from 2 test pits in the bottom of the construction borrow area.

Excavation and inspection of the area in the vicinity of the right upstream end of the outlet pipe (Photograph 3) revealed several interesting items. The cutoff collars seemed to be very tight

around the outlet pipe with no separation or gap between the concrete and the pipe (Photograph 4). Very fine cracks were observed extending partially through the radiuses of two of the collars. The erosion route followed along the left side of the pipe and turned right around and behind the valve control riser (Photograph 5) before going out of sight along the pipe. The erosion extended to the left, above, and below all of the cutoff collars (Photographs 6 through 8) between the upstream end of the pipe and the valve control riser, with only the right edges and a bit of the top and bottom of each collar remaining in contact with the compacted embankment. With only two exceptions, wherever the pipe or collars were in contact with the embankment, that contact was tight. One exception was a small gap of about ½ inch along the right outside edge of the second collar (Photograph 9). This can probably be attributed to slight rotation or settlement toward the left after the pipe became unsupported after erosion around the pipe and collars. The other exception was around the valve control riser where a gap of approximately ½ inch was noticeable between the pipe and surrounding fill (Photograph 10). Vertical extent of the crack could not be determined.

There was a halo of frozen embankment around the outlet pipe that extended outward about 8 to 10 feet at least toward the right side. No ice lenses or isolated ice masses were noted along the pipe, cutoff collars, or in the embankment. The frozen, compacted fill was very hard to excavate and appeared to be of similar consistency both near and away from the pipe. All looked to be dark gray recompacted glacial till classifying as CL. Some layering was noted because of color changes in the material. This was most noticeable low in the eroded tunnel wall to the left side of the outlet pipe (Photograph 6) and above the pipe where the layers have separated due to lack of support (Photograph 11). Ten Troxler densities taken near the pipe (Photographs 12 and 13) during excavation showed an average dry density of 98.4 lbs/ft3 and an average moisture of 18.1%. The average percent compaction compared to the target Proctor maximum dry density of 107.0 lbs/ft3 was therefore only about 92% - about 3% below the acceptable amount. Approximately 5 feet to the right of the pipe 8 Troxler densities had an average dry density of 102.2 lbs/ft3 and an average moisture content of 18.0%. The average percent compaction was right on the acceptable goal of 95%. These figures indicate that the special compaction around the pipe was not as good as the compaction that was achieved farther away, and did not quite meet the original compaction goal of 95%. Possibly measurements from the new Troxier do not correlate with those from Troxlers used during construction, or the most recent measurements were influenced by the frozen condition of the fill. The Troxler moisture contents both near the pipe and five feet away were very close to the goal of 17% plus or minus 1%, so the moistures do seem to correlate.

In order to verify earlier laboratory data and Troxler measurements, and to obtain additional materials data, several samples of compacted fill were collected from the vicinity of the right upstream end of the outlet pipe in the area that remained intact after the piping failure. Two samples were from near the top elevation of the pipe - one about 1 foot right of the pipe and the other about 8 feet right, and a third was taken from near the bottom elevation of the pipe and about 1 foot to the right. Laboratory data from all three samples were nearly identical. They all classified as Lean Clay With Sand (CL) with sieve analyses and hydrometers indicating an average content of approximately 46% clay fines, 30% sit fines, 22% sand, and 2% mostly fine gravel. Atterberg Limits showed the liquid limits (LL) to be either 45 or 46% and all the plasticity indices (PI) to be 32%. The Proctor maximum dry densities varied from 105.2 to 105.7 Ibs/t² at moisture contents ranging from 17.0 to 19.3%. These Proctor maximum dry densities are thus only slightly less than the original design target of 107.0 lbs/t², and the moisture range was also very near the target moisture of 17.0% plus or minus 1%. Two natural moisture content tests



yielded 17.0 and 17.7% - right at the target moisture content and also correlating well with the recent Troxler moistures

The rapidity with which the piping failure occurred suggested that laboratory tests should be conducted for dispersive clays in the compacted fill. Two samples from the sites near the top elevation of the outlet pipe were submitted to a contract laboratory for analyses. This suite of four tests (pinhole, crumb, SAR, and total dissolved salts - TDS) indicated the definite probability of dispersive soils in both samples. The results were a surprise to the board of inquiry because none of us has ever had any experience with dispersive clays in the continental till of northern Montana. Undoubtedly, the dispersive nature of the till soils can be attributed to the high percentage of sodium-rich Bearpaw Shale fragments contained within the till. Several large dams have been constructed by Reclamation in the area using similar appearing materials without any piping problems developing. As far as can be determined, however, the fill from one of those dams has ever been tested for dispersive clays.

A skid-mounted, still camera (Photograph 14) was used by personnel from the State of Montana to photograph the inside of the outlet pipe, but the photographs have not yet been made available, so the presence or absence of gaps or irregularities in the pipe is unknown.

The resurvey of reference points across the crest of the dam indicated that there was probably a minor error in the initial survey which showed a settlement of about 0.2 feet in the maximum section of the structure and a similar settlement on the tops of the vertical riser pipes. It is now believed that the settlement is about half that. Unfortunately, no conclusion can be made as to whether the settlement occurred prior to - and could have been a contributing factor in the failure, or happened after the failure because of removal of supporting material around the outlet pipe.

Inspection of the emergency spillways revealed nothing unusual. They seem to have sufficient width and probably length to safety pass flows of short duration. It appears, however, that it might have been preferable to have extended the west end of the dam slightly farther to the north rather than curving it close to the high bank near the creek. If erosion should occur near the end of the dam, the short distance to the bank could start rapid headward cutting into the reservoir. Surficial material appears to be glacial till similar to that encountered in most of the excavations.

An inspection of about ½ mile of the downstream outlet channel (Photograph 15) also did not reveal anything of an unusual nature. The excessive erosional holes that had been reported were not found - possibly because they were filled with water and ice. Erosion that was evident appeared to be caused by normal variances in topography coupled with the abnormal outflow being carried by the small channel.

During the filling and evacuation of the reservoir, observers noted the presence of several small whirlpools upstream from the dam. Normally these form over sinkholes, so the floor of the reservoir was carefully inspected. A few small depressions were found (Photograph 16), but none exceeded a foot or so across and a few inches deep. The nature of the local geology (being mostly impervious alluvium and glacial deposits overlying Bearpaw Shale), does not lend itself to the formation of sinkholes. The most probable causes of the depressions are reservoir water entering into underlying joints in the till or into discontinuous pervious outwash or alluvial deposits that had been previously drained by construction activities at the dam. Water movement into these openings would have carried some soil fines from the overlying material,

and caused the small depressions. The vortexes were possibly the result of this temporary water movement into the openings, and ceased once the openings were saturated.

Inspection of the riprap (Photograph 17) revealed it to be a sound, heavy igneous rock of good quality. It is angular, freshly quarried rock of reasonably good gradation and large enough to adequately protect the structure from waves produced from the short fetch of the reservoir.

While a backhoe was available at the reservoir site, three test pits were excavated around the reservoir rim just east of the borrow area that had been used for embankment construction. They were numbered TP97-101 through -103 in a progression from south to north (Investigations Location Map - Appendix B). The purpose of the pits was to determine the characteristics of the material in that area for its possible use as impervious fill in dam reconstruction. Most of the material encountered was glacial till classifying as Lean Clay With Sand (CL), but each pit had somewhat differing materials. A detailed geologic log of each pit is included in Appendix D.

Material in TP97-101 (Photograph 18) was all glacial till to a depth of 9.0 feet with a concentration of light colored minerals between 1.0 and 4.0 feet. These minerals occur as white granules and crystals and appear to be mostly gypsum. Because of the mineral concentration, the top portion of this pit probably is unsuitable for fill. A sample of the mineralized zone was tested for dispersive clays with the result being a possible dispersion problem. A rather unusual blocky texture was noted for most of the materials in this pit.

In TP97-102 (Photograph 19), the upper 6.5 feet of material was glacial till with some accumulation of minerals between 1.0 and 2.0 feet. The lower part of the pif from 6.5 to 9.5 feet was Sandy Lean Clay (CL) with a nearly even mixture of fine sand and low plasticity fines. This material had a light brown color that contrasted with the surrounding gray or brownish-gray till. It is probably a buried lacustrine sediment. If properly mixed, the materials from this pit could be used for impervious fill, but better materials are locally available. No samples from the pit were tested.

The materials in TP97-103 (Photograph 20) appeared to be almost a combination of the other two pits. From the surface to 8.0 feet, the material was overall a gray colored glacial till. It did, however, contain areas of light brown soils that looked like the lacustrine sediment observed in the lower part of TP97-102. A zone from 1.5 to 3.0 feet showed a slight accumulation of light colored minerals. From 8.0 to 11.0 feet, material excavated from the pit was typical glacial till. If properly mixed, material from the pit would be suitable for impervious fill. No samples from the pit were tested.

When it became apparent that material from the east rim of the original construction borrow area was not very consistent and of somewhat questionable quality, it was decided to further investigate the bottom of the original borrow area. Two test pits were excavated in that area. Pit TP97-104 was completed to the west, and TP97-105 to the east. Each pit had somewhat different material. Geologic logs are included in Appendix D.

From the ground surface to a depth of 10.0 feet, TP97-104 (Photograph 21) was excavated into gray-brown glacial till classifying as Lean Clay With Sand (CL). The material had good moisture (probably near optimum moisture content), and contained a few scattered gypsum crystals. This area had previously been excavated well below the zone of shallow mineral accumulation, so mineral concentration was not observed. The excavated material appeared quite suitable for use as impervious fill. No samples of materials were collected or tested.

Test pit TP97-105 (Photograph 22) contained two distinctive types of material easily distinguished by color and Atterberg Limits test data, but similar in overall gradation. Both materials classified as Lean Clay With Sand (CL). The upper unit was encountered from 0 to 4.0 feet. It was gray-brown in color, moist, and contained scattered gypsum crystals. A liquid limit value of 46% was obtained along with a plasticity index of 31%. It looked like the glacial till that had previously been used from this borrow area for dam construction, and tested almost identically (Appendix E). The lower unit extended from 4.0 to 10.0 feet. It was light brown in color and moist, but the gypsum crystals of the upper unit extende absent. The liquid limit was 34% and the plasticity index was 20% - both much lower than the upper unit. This material appeared to be a lacustrine sediment. When mixed with the overlying unit, this material would be suitable for use as imprevious fill.

Overall characteristics of the material from this original construction borrow area appear to be superior to that of materials from the adjacent reservoir rim area to the east. Further utilization of this existing borrow area would also require less reclamation than expanding the present borrow area into the rim area which has already been restored.

Conclusions

The investigations completed in this phase of the Board's inquiry into the failure of Anita Dam did not reveal the exact methodology of failure, and I do not expect that will ever be known because most of the evidence was washed away. Much of the new information confirms preconstruction design data and construction quality control conclusions. Other information seems to refute some failure suppositions. Only one previously unknown major contributing factor to the failure was disclosed by these investigations.

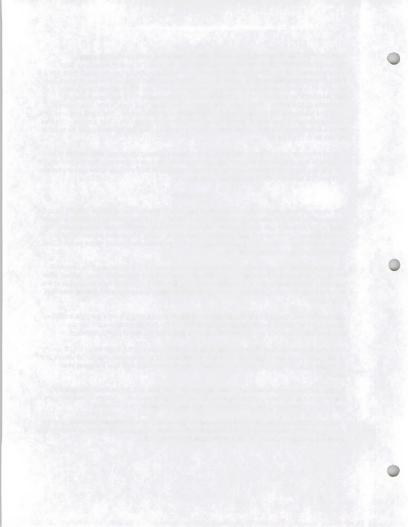
Excavation and testing in the vicinity of the outlet pipe revealed that there was little physical difference between the material compacted next to the pipe and that farther away, as had been proposed by the contractor. Gradations, moistures, and Atterberg Limits data showed all of the material to be the same, and also nearly identical to material remaining in the borrow area that was utilized.

Compaction (as revealed by in situ density data) was not quite as good near the pipe as farther away, and may not have met the target goal of 95% of the design maximum dry density. Moisture contents of the excavated material were very near the target design moisture.

With only two exceptions, remaining contacts of the compacted embankment with cutoff collars or the metal pipes were tight, and there was no evidence of gaps between the cutoff collars and the outlet pipe. Erosion proceeded completely around the collars as if they were not even present.

A halo of frozen embankment extended out from the right side and above the outlet pipe for a distance of 8 to 10 feet. It made the material very difficult to excavate. No ice lenses or layers were found either along the pipe or in the surrounding compacted embankment.

Inspection of the reservoir floor did not reveal the presence of any significant sinkholes, and the geology of the dam site generally precludes their formation. The cause of the small vortexes that were observed in the reservoir cannot be adequately explained.



The excavation of test pits in the original borrow area revealed it to be a logical source of additional impervious fill for embankment reconstruction.

The most significant finding of the latest investigations was the presence of dispersive clays in the glacial till used for embankment construction. This was a totally unexpected revelation because there is no history of previous problems with continental till deposits in this area. The designer could not reasonably have been expected to anticipate this problem. It can only be detected by rather elaborate laboratory testing not commonly required for construction design. If the presence of these highly erodible soils had been known, the design of the structure could have been modified to account for them or the construction material treated to alleviate the condition.

It is my opinion that determining the exact cause and location of the initial conduit for the piping failure is an honorable but unrealistic goal, and is irrelevant anyway. Investigations of Anita Dam have indicated that the dam site is located in a geologically favorable site, and with proper design modifications, the dam can be safely reconstructed. That should be confirmed by the final phase of ongoing investigations.

Recommendations

The final phase of investigations should be completed and the results analyzed to determine if any additional information about the embankment or foundation conditions will influence a decision to redesign and reconstruct the dam. Those final investigations involve drilling a total of 5 holes in the embankment and foundation of the structure to determine the characteristics of both the embankment and foundation materials. Four of the holes will be drilled along the dam axis and the other upstream near the vertical risers for the valve control structure and the overflow spillway. Standard Penetration Tests will be conducted to evaluate the bearing capacity of the embankment and foundation materials and locate any soft zones. Two undisturbed samples will be collected for one-dimensional consolidation testing of core trench and foundation materials near the vertical structures. Representative samples will be collected for sieve analyses, hydrometer tests, moisture tests, Atterberg Limits, and the suite of four tests used to identify dispersive clays. Double porous tube piezometer installations will be completed in each of the outside axis holes.

This final drilling and testing phase of investigations began on May 1, 1997, and was concluded by the first of June. Commercial laboratory testing and final report preparation will take until approximately the end of June.

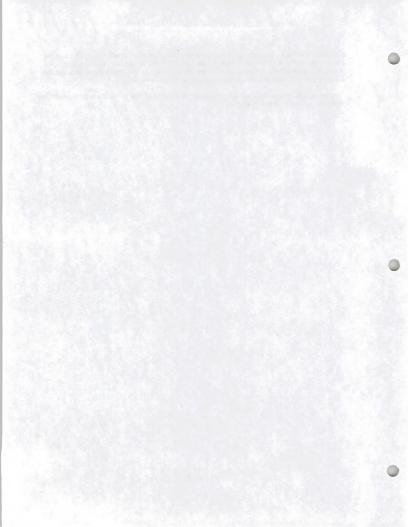
In addition to the formal investigation programs that will soon be completed, a very careful excavation of the outlet pipe should be conducted. Personnel familiar with the structure and its construction, and knowledgeable of the various theories of failure proposed by the Board of inquiry, should be present throughout the procedure to look for any evidence of a failure mechanism that might be uncovered.

If a final decision is made to reconstruct the dam, I would urge that the latest design criteria and construction procedures be followed for structures containing dispersive clays. As a minimum, I think this would involve bedding an outlet pipe (without cutoff collars) in a slurry of soil-cement or concrete up to the middle of the pipe; compacting over the remainder of the pipe with pneumatic tired equipment until a sufficient amount of cover is achieved; and installing a filter and drainage system around the downstream portion of the pipe to control any seepage and piping of



dispersive materials. As extra safety factors, a complete filter blanket with toe drains could be constructed on the downstream face of the dam, and all material used for reconstruction (especially around the outlet pipe) could be treated with calcium chloride or some other suitable substance to help alleviate the dispersive properties of the local soils.

Above all, I recommend a thorough peer review of the final design by someone familiar with the problems caused by dispersive soils.



APPENDIX A
BIBLIOGRAPHY



BIBLIOGRAPHY

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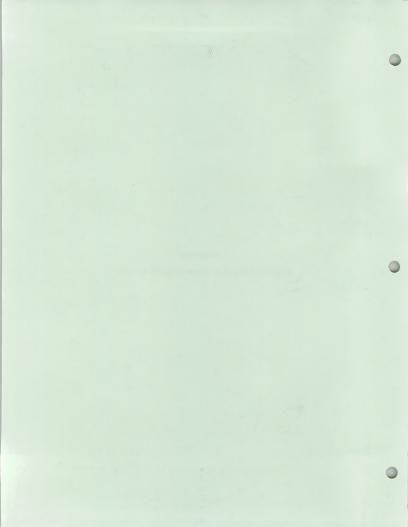
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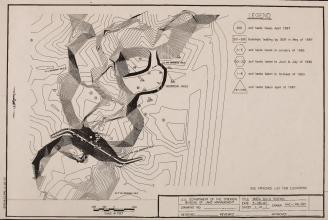
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APPENDIX B

INVESTIGATIONS LOCATION MAP AND SURVEY DATA







ANITA SOILS TESTING TO ACCOMPANY THE ANITA SOILS TESTING DRAWING LRB, BO, HAC

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page 1 of 2

The following as a list of all test holes and pits taken at Anita Reservoir. All the samples with exception of the 200 series, were backhoe excavated test pits.

The first eight samples were taken in October of 1993 and the elevations are as follows:

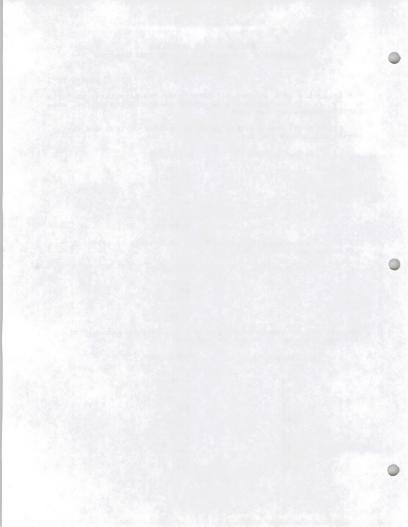
Sample Number	Elevation		
1	2681.58		
2	2691.71		
3	2702.12		
4	2714.29		
5	2696.17		
6	2714.42		
7	2714.40		
8	2693.08		

The following samples(A-E) were taken in January of 1995 and the elevations are as follows:

Elevation		
86.45		
7.90		
8.38		
8.34		
2.97		

The next set of samples(20-32) were taken in June and July of 1995 and the elevations are as follows:

Sample Number	Elevation
20	2724.07
21	2724.65
22	2722.37
23	2724.50
24	2721.48
25	2724.73
26	2724.66
27	2723.87
28	2723.75
29	2689.64
30	2694.81
31	2692.03
32	2696.97



The following samples(101-105) were taken on April 11, 1997 by BOR and BLM and the elevations are as follows:

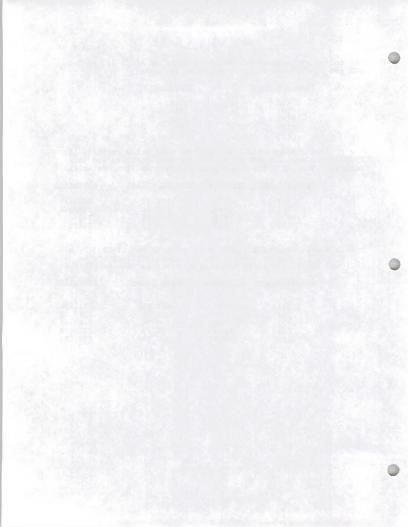
Sample Number	Elevation		
101	2718		
102	2718		
103	2715		
104	2694		
105	2693		

The following samples(301,303,304,305) were taken on April 15, 1997 by BOR and BLM and the elevations and locations are as follows: (Station offsets are plus if upstream from centerline)

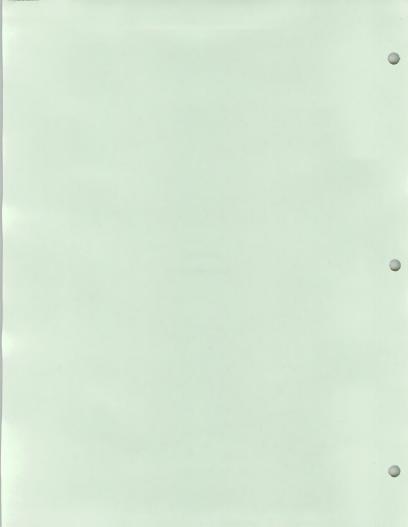
Sample Number	Station	Station Offset	Elevation
301	5+45	+80 ft	2697.10
303	5+45	+80 ft	2688.58
304	5+51	+80 ft	2688.98
305	5+45	+69 ft	2689.02

The following samples (201-205) were taken in May of 1997 by BOR and BLM by the use of a drill rig and the elevations are as follows: (Station offsets are plus if upstream from centerline)

Sample Number	Station	Station Offset		Elevation
201	5+45	+34 f	t	2711.70
202	7+36	0 f	t	2720.00
203	6+06	0 f	t	2720.00
204	4+96	0 f	t	2720.00
205	3+30	0 f	t	2720.00



APPENDIX C
PHOTOGRAPHS

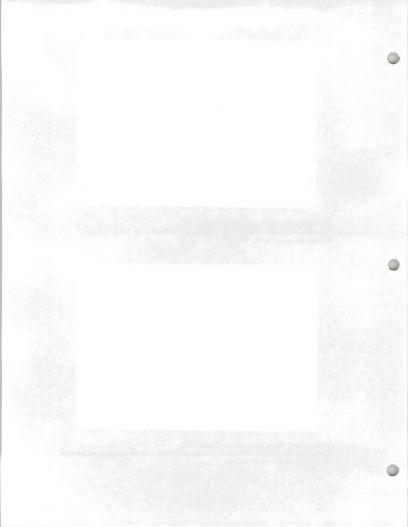




Photograph 1 Anita Dam - Blaine County - MT Upsteam end of the outlet pipe showing an eroded area to the left of the pipe. Photograph by L. Parish 4-10-97



Photograph 2 Anita Dam - Blaine County - MT Downstream end of the outlet pipe showing an eroded hole on each side of the pipe. Photograph by L. Parish 4-10-97

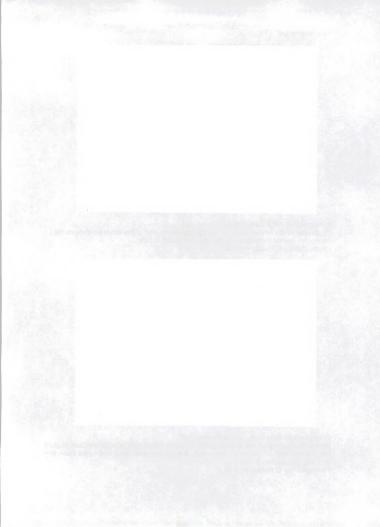




Photograph 3 Anita Dam - Blaine County - MT Excavation of the embankment on the right upstream side of the outlet pipe where the material remained in contact with the pipe and cutoff collars. Photograph by L. Parish 4-10-97



Photograph 4 Anita Dam - Blaine County - MT View of the outlet pipe and a cutoff collar. The collar appeared to be in complete contact with the pipe with no gap between the two. A single very fine crack was noted extending part way through two collars. Photograph by L. Parish 4-10-97

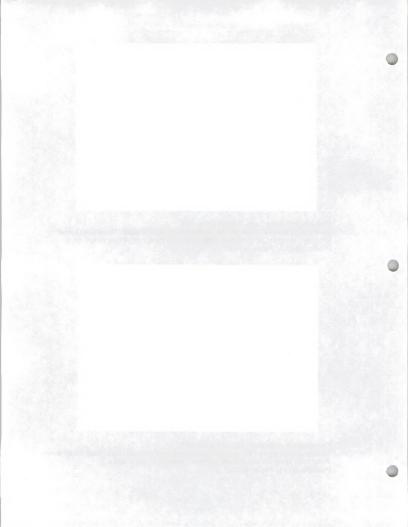




Photograph 5 Anita Dam - Blaine County - MT View looking downstream along the outlet pipe and cutoff collars. The eroded tunnel turns right along the pipe just downstream from the valve control riser (bright spot). Photograph by L. Parish 4-10-97



Photograph 6 Anita Dam - Blaine County - MT Another view of erosion along the left upstream part of the outlet pipe. Note the lift layers at the base of the left wall that are defined by differing material colors. Photograph by L. Parish 4-10-97

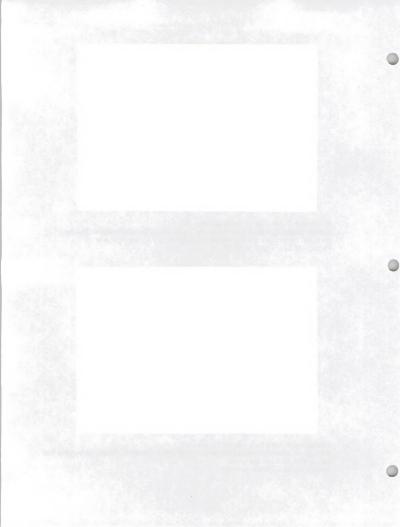




Photograph 7 Anita Dam - Blaine County - MT
Erosion extending around the left side and above one of the cutoff collars. The only
portion in contact with the compacted embankment is the lower right side.
Photograph by L. Parish 4-10-97



Photograph 8 Anita Dam - Blaine County - MT
Photograph showing erosion extending beneath one of the cutoff collars. Note riprap that
was carried back into the tunnel.
Photograph by L. Parish 4-10-97

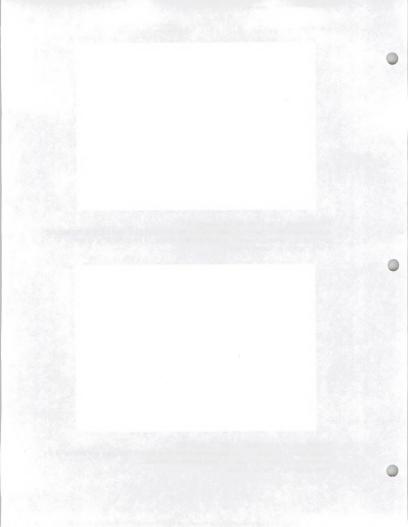




Photograph 9 Anita Dam - Blaine County - MT Gap of about ½ inch between compacted embankment and the right edge of the second cutoff collar probably caused by settlement and rotation of the collar after erosion. Photograph by L. Parish 4-10-97



Photograph 10 Anita Dam - Blaine County - MT Gap of about ½ inch at the contact between the valve control riser pipe and the top of the embankment. Depth of the crack could not be determined. Photograph by L. Parish 4-10-97

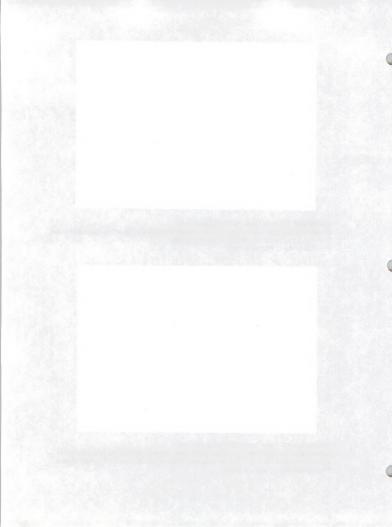




Photograph 11 Anita Dam - Blaine County - MT Separation along lift lines where they are exposed above the top of the first cutoff collar. They have sagged downward after losing support. Photograph by L. Parish 4-10-97



Photograph 12 Anita Dam - Blaine County - MT View of the right upstream part of the outlet pipe showing compacted embankment in tight contact with the pipe. Troxler data was obtained about a foot to the right of here.

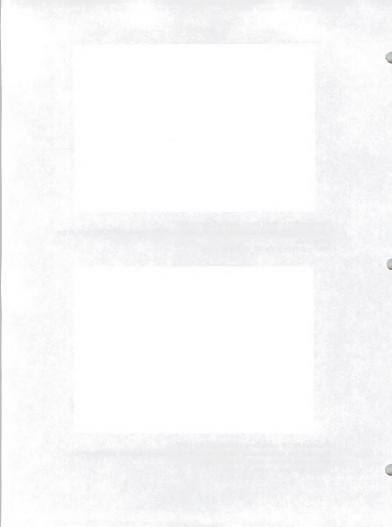




Photograph 13 Anita Dam - Blaine County - MT Completing Troxler density and moisture measurements above and to the right of the outlet pipe. Photograph by L. Parish 4-10-97



Photograph 14 Anita Dam - Blaine County - MT Picture of the skid-mounted still camera used by State of Montana engineers to photograph the interior of the outlet pipe. Photograph by L Parish 4-10-97

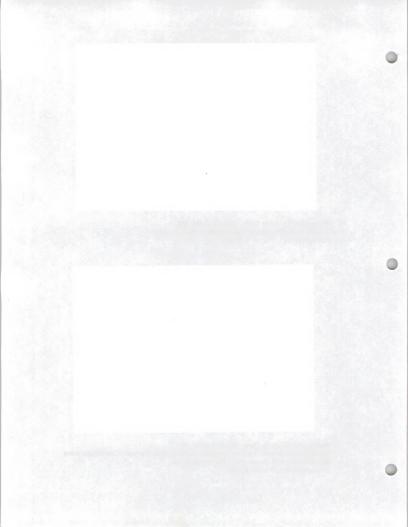




Photograph 15 Anita Dam - Blaine County - MT View of the creek channel downstream from Anita Dam. Photograph by L. Parish 4-10-97



Photograph 16 Anita Dam - Blaine County - MT Small depressions on the reservoir floor upstream from the dam. The largest were slightly over a foot across and a few inches deep. Photograph by L. Parish 4-2-97

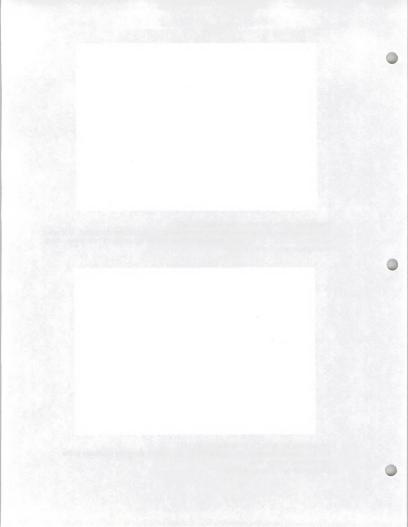




Photograph 17 Anita Dam - Blaine County - MT View toward the left abutment showing the heavy igneous rock used for riprap. It appears to be of sufficient size, durability, and gradation to protect the structure from wave action. Photograph by L. Parish 4-10-97



Photograph 18 Anita Dam - Blaine County - MT Pile of material excavated from test pit TP97-101 located along the south rim of the construction borrow area. Photograph by L. Parish 4-10-97

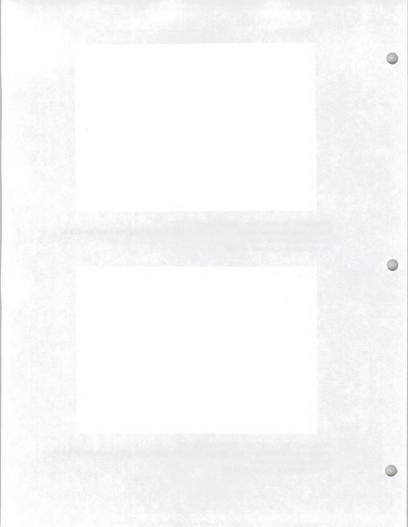




Photograph 19 Anita Dam - Blaine County - MT
Pile of material excavated from test pit TP97-102 located along the south rim of the construction borrow area.
Photograph by L. Parish 4-10-97



Photograph 20 Anita Dam - Blaine County - MT
Pile of material excavated from test pit TP97-103 located along the south rim of the construction borrow area.
Photograph by L. Parish 4-10-97

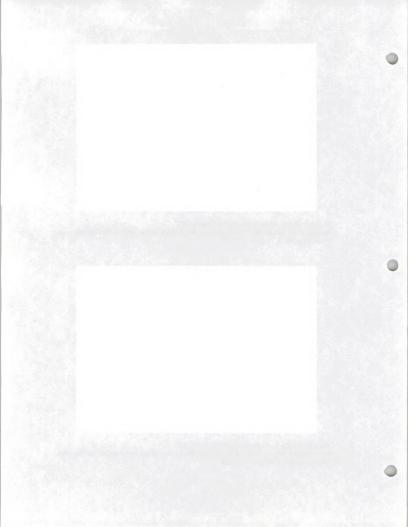




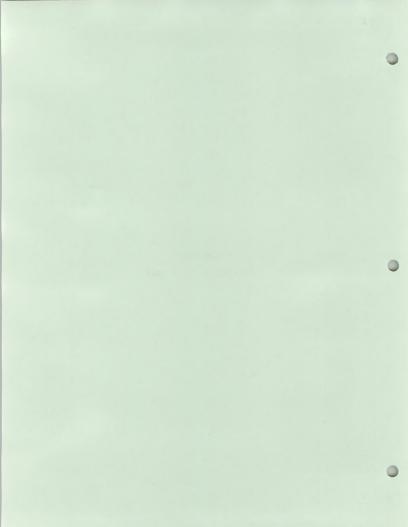
Photograph 21 Anita Dam - Blaine County - MT Material from test pit TP97-104 located in the bottom of the construction borrow area. Photograph by J. Rogers 5-16-97



Photograph 22 Anita Dam - Blaine County - MT Material from test pit TP97-105 located in the bottom of the construction borrow area. Photograph by J. Rogers 5-16-97



APPENDIX D
POST-FAILURE TEST PIT LOGS





Fax Cover Sheet

FROM: Jan Seckel
TO: Greg Bergum
AGENCY: Bureau of Land Management
LOCATION: Billings, MT
FAX NUMBER: 255-2762
VERIFICATION NUMBER:

PAGES (Including this sheet): 2

Subject: Corrected drill log.

Please insert the attached corrected drill log into the report titled, "Geotechnical Investigations Report of the Piping Failure of Anita Dam," by Lovell Parish, dated June 1997. This report was mailed to you early last week. The corrected drill log should replace TP97-104 in Appendix D. It corrects the percentage 25% to 20% on the second line in the description of material section.

From the desk of ...

Jan Seckel Geology Group - GP Region Bureau of Reclamation P.O. Box 36900 Billings, MT 59107-6900

> Phone: (406) 247-7813 Fax: (406) 247-7793

- ☐ Hard Copy Following
- ☐ Action
- ☐ As Requested
- □ Comments
- ☐ For Your Information
- ☐ As Per Conversation
- ☐ For Signature



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Total Company

Market Mills Committee of the Committee

7-1336-A (1-86) Bureau of Recian	IMALIOU LOG OF TEST PIT OR AUGER HOLE HOLE NO. TP47-1				-104	1
COORDINATES APPROXIMATE	TION Main Borrow Area N ** E DIMENSIONS 4'XIO'X 10'	METHOD OF EXPLORA	Ribure Invest 2694 TION Backhoe	iqa	tio	_
CLASSIFICATION GROUP SYMBOL	Daito Dan Doith Daith Dan Descript OR AUGER HOLE MATON MATON Main Bourson Area GROUND ELEVATION 2694 MET DIMENSIONS 4'X10'X10' DATE METHOD OF EXPLORATION Backhae LOGGED BY LO	(BY	LUS 3	in		
(describe sample taken)	SEE USBR 5000, E	0005		3 - 5 in	5- 12 in	PL.
CL.	predominantly fine sar coarse, hard subrounds gray-brown; woist; s crystals; maximum s reaction with HCI.	n plasticity nd; about 5 ed to rounde cattered gy nize - 6 inch	; about 202 2 fine to d gravel; pown res; weak	tr	tr	
10.094	GEOLOGIC INTERPRETATION	N: Quaterna	ny glacial			
	· See Investigations Loca	tion Was				
HEMARKS:	es collected.	cher map				

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	HOLE NO. TP47-105
1.1.0	2	

FEATURE Anita Dam

AREA DESIGNATION Main Borray Area

GROUND ELEVATION 2693

METHOD OF EXPLORATION BACKING.

APPROXIMATE DIMENSIONS 4'X10' LOGGED BY L. Parish

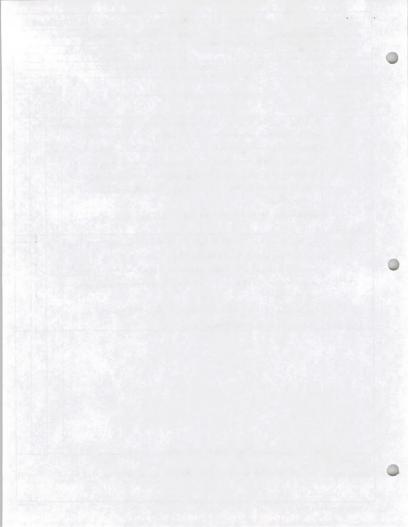
DEPTH WATER ENCOUNTERED 1/ Dry DATE 4-10-97

DATE: SI LOGGED 4-10-97

		VOLU	
SEE USBR 5000, 5005	3 · 5 in	5 - 12 in	PLUS 12 in
with low to medium plasticity; about 20% predominantly fine sand; about 5% fine to coarse subrounded to rounded gravel; gray-brown; moist; Scattered gypsum crystals; maximum size - 6 inches; weak reaction with HCI.	++	tr	
till.			
with slight to low plasticity; about 25% fine sand; trace of fine gravel; light brown; moist; maximum size-11/2 inches; weak reaction with HCI.			
laustrine sediment.			
	0.0 to 4.0 ft LEAN CLAY WITH SAND: About 75% fines to with low to medium plasticity; about 20% predominantly fine sand; about 5% fine to coarse subrounded to rounded gravel; gray-brown; moist; scattered gypsum crystals; maximum size - 6 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till. 4:0 to 10.0 ft SANDY LEAN CLAY: About 75 % fines with slight to low plasticity; about 25% fine sand; trace of fine gravel; light brown; moist; maximum size - 11/2 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005 O.O to 4.0 ft LEAN CLAY WITH SAND: About 75% fines to with low to medium plasticity; about 20% predominantly fine sand; about 5% fine to coarse subvounded to rounded gravel; gray-brown; moist; Scattered gypsum crystals; maximum size - 6 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till. 4.0 to 10.0 ft SANDY LEAN CLAY: About 75% fines with slight to low plasticity; about 25% fine sand; trace of fine gravel; light brown; moist; maximum size - 1/2 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005 O.O to 4.0 ft LEAN CLAY WITH SAND: About 75% fines to with low to medium plasticity; about 20% predominantly fine sand; about 5% fine to coarse subrounded to rounded gravel; gray-brown; moist; Scattered gypsum crystals; maximum size - 6 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till. 4.0 to 10.0 ft SANDY LEAN CLAY: About 75% fines with slight to low plasticity; about 25% fine Sand; trace of fine gravel; light brown; moist; maximum size - 1/2 inches; weak reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary

REMARKS:

Samples: 50 16 sacks from 0 to 4.0 ft and 4.0 to 9.0 ft.



LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP97-101

FEATURE Anita Dam

AREA DESIGNATION South EAGL OF BOXOND Area

COORDINATE IN * E

APPROXIMATE DIMENSIONS 4' X 10' X 9'

APPROXIMATE DIMENSIONS 4' X 10' X 9'

DATE 4-10-47

PROJECT Piping Failure Investigation
GROUND ELEVATION 2718

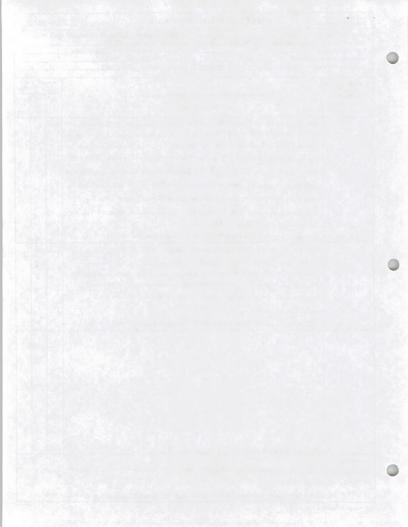
AFTHOROUGH PARTY AND PARTY AND ALTER LOGGED BY L. Phrish
PARTY 4-10-97
PARTY BATES LOGGED 4-10-97

CLASSIFICATION GROUP		% PLUS 3 in (BY VOLUME)			
SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	3 - 5 in	5 - 12 in	PLU 12 in	
4.0 ft	0.0 to 4.0 ft LEANCLAY WITH SAND: About 75% fines with low plasticity; about 20% predominantly fine sand; about 5% fine to coarse, hard, subrounded to rounded gravel; brown-mostly topsoil from 0 to 1.0 ft; dark gray with white spots and mottling below 1.0 ft; moist; heavy concentration of minerals-mostly gypsum granules and crystals; blocky texture from 1.0 to 4.0 ft; maximum size-tinches; strong reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till	tr			
9,0 ft	4.0 to 9.0 ft. LEAN CLAY WITH SAND: About 75% fines with low plasticity; about 20% predominantly fine sand; about 5% fine to coarse, hard, subrounded to rounded gravel; gray-brown; moist; scattered gypsun crystals; maximum size - 4 inches; strong reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till.	++			
	* See Investigations Location Map				

REMARKS

Samples: 50 16 composite sample from 0 to 9.0 ft. Two quart jars from 1.5 to 4.0 ft.

Note: Would not use material from 1.0 to 4.0ft because of minerals.



LOG OF TEST PIT OR AUGER HOLE

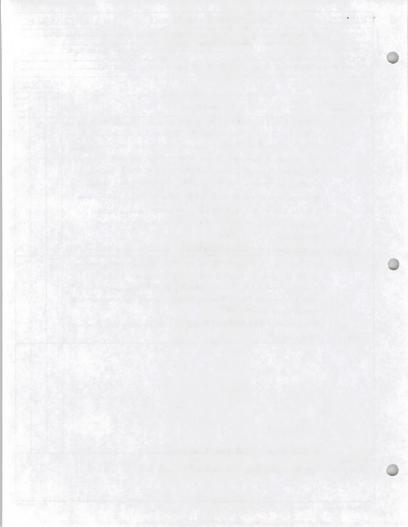
HOLE NO. TP97-102

FEATURE Anita Dam AREA DESIGNATION South Edge of Borrow Area COORDINATES N * APPROXIMATE DIMENSIONS 4'X10'X 4.5'

PROJECT Piping Failure Investigation GROUND ELEVATION 2718 METHOD OF EXPLORATION Backhoe LOGGED BY L. Parish DEPTH WATER ENCOUNTERED 1/ Dry DATE 4-10-97 DATE(S) LOGGED 4-10-97

CLASSIFICATION GROUP			% PLUS 3 in (BY VOLUME)		
SYMBOL (describe sample taken)	(describe SEE USBR 5000, 5005		5 - 12 in	PLU: 12 in	
CL	0.0 to 6.5 ft LEAN CLAY WITH SAND: About 75 % fines with low plasticity; about 20 % predominantly fine sand; about 5 % fine to coarse, hard, subrounded to rounded gravel; brown - mostly topsoil from 0 to 1.0 ft; gray with white spots and some mottling from 1.0 to 2.0 ft; mixed gray and brown from 2.0 to 6.5 ft; blocky texture from	tr			
6.5 ft	1.0 to 2.0 ft; scattered gypsum crystals; moist; maximum size - 5 inches; strong reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary glacial till				
CL	6.5 to 9.5 ft SANDY LEAN CLAY: About 60% fines with slight to low plasticity; about 40% predominantly fine sand; light brown; moist; maximum size-coarse sand; weak to moderate reaction with HCI.				
9.5 ft	GEOLOGIC INTERPRETATION: Quaternary lacustrine Sediment				
	* See Investigations Location Map				

Samples: 50 16 sacks from 0 to 6.5 ft and 6.5 to 9.5 ft.



HOLE NO. TP 97-103

FEATURE ANITA Dam

AREA DESIGNATION South Edge of Borrow Area

COORDINATES N # E

APPROXIMATE DIMENSIONS 4' X 10' X 11'

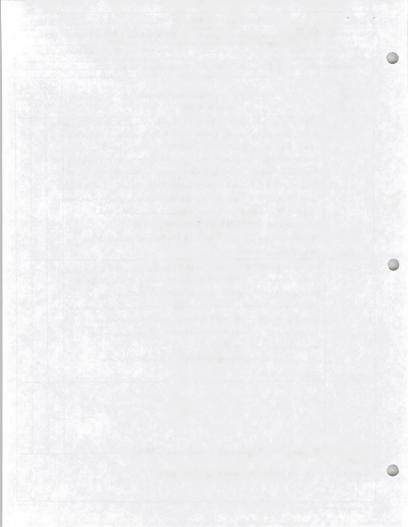
DEPTH WATER ENCOUNTERED 1/ Dry DATE 4-10-97

PROJECT Piping Failure Investigation
GROUND ELEVATION 2715
METHOD OF EXPLORATION Backhoe
LOGGED BY L. Parish
DATESS LOGGED 4-10-97

CLASSIFICATION GROUP			VOLL	
SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	3 - 5 in	5 - 12 in	PLU 12 in
8.0 Ft	0.0 to 8.0 ft. LEAN CLAY WITH SAND: About 75% fines with low plasticity; about 20% predominantly fine sand; about 5% fine to coarse, hard, subvounded to rounded gravel; brown - mostly topsoil from 0 to 1.5 ft; gray with white spots from 1.5 to 3.0 ft - mineralized zone; gray and brown mixed from 3.0 to 8.0 ft; moist; maximum size - 5 inches; strong reaction with HCI. GEOLOGIC INTERPRETATION: Mostly Quaternary glacial till with some mixed lacustrine sediments			
CL	8.0 to 11.0 ft LEAN CLAY WITH SAND: About 75% fines with low to medium plasticity; about 20% predominantly fine sand; about 5% fine to coarse, hard, subrounded to rounded gravel; rusty gray; moist; numerous gypsum crystals; maximum size-5 inches; no reaction with HCI. GEOLOGIC INTERPRETATION: Quaternary	++		
11.0 \$}	glacial till. * See Investigations Location Map			

REMARKS

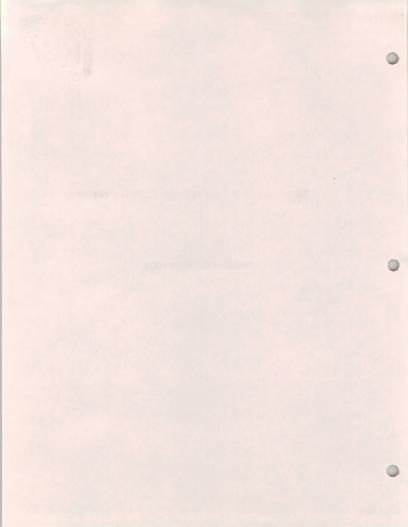
Sample: One 5016 sack from 0 to 8.0ft.



APPENDIX E
POST-FAILURE LABORATORY TEST DATA



PHYSICAL PROPERTIES TESTS



MSE - HKM, Inc.
277 Central Avenue
P. Q Box 31318

Billings, MT 59107-1318 (406) 656-6399

FAX (406) 656-6398

April 25, 1997 F:\WP\11\W145115\JDL01289.DOC

Mr. Lovell Parish U.S. Bureau of Reclamation P.O. Box 36900 Billings, MT 59107-6900

RE: Anita Dam Materials Testing (Call #5)

Dear Lovell:

Enclosed are the results of tests performed on the five (5) soil samples that were delivered to our lab on April 14, 1997.

As requested, natural moisture content testing was only performed on samples #11812 and #11813.

Should you have any questions or comments, please contact us at your convenience.

Sincerely,

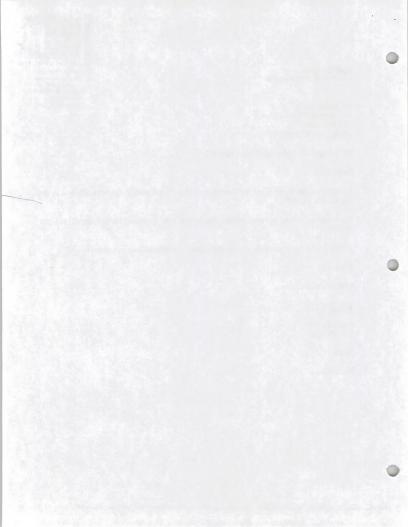
MSE-HKM, Inc.

Ray Fil

Randy Fincher Lab Manager

RF/jdl

Enclosures



7-1734 (8-71) Bureau of Reclamation

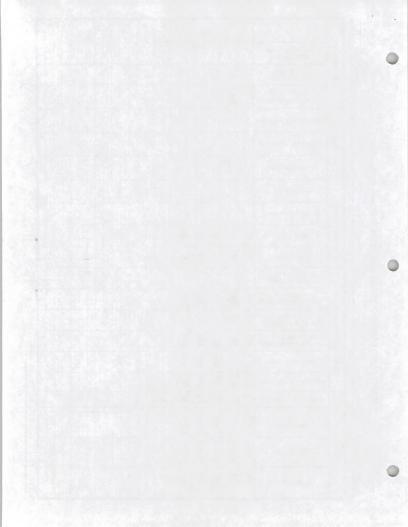
SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS (Proctor Compaction)

Project: Anita Dam - Blaine County, Montana

Feature:

Table: 5 Sheet 1 of 1

1	DENTIFICATIO	ON .		P	ARTICLE	-SIZE FF	RACTION	ıs		CONSI	STENCY	LIMITS	- 1	SPECIFIC	GRAVIT	Y	С	OMPAC	TION TEST
SAMPLE NUMBER	HOLE NUMBER	DEPTH - Feet (m)	CLASSIFICATION SYMBOL	SMALLER THAN 0.005 mm	0.005 TO 0.074 mm	SAND NO. 200(0.074 mm TO NO. 4(4.76 mm)	GRAVEL NO. 4(4.76 mm) TO 3 IN.(76.2 mm)	COBBLES 3 IN.(76.2 mm) TO 5 IN.(127 mm)	OVERSIZE LARGER THAN 5 IN.(127 mm)	LIQUID LIMIT - %	PLASTICITY INDEX - %	SHRINKAGE LIMIT - %	MINUS NO. 4	BULK - PLUS NO. 4	APPARENT - PLUS NO. 4	ABSORPTION-PLUS NO. 4 %	MAXIMUM DRY DENSITY - pcf (gm/cm3)	OPTIMUM WATER CONTENT - %	PENETRATION RESISTANCE - PSI
11812	SAMPLE #3	N/R	CL	46.9	28.5	22.1	2.5	0.0		46	32						105.2	19.3	
11813	SAMPLE #4	N/R	CL	47.3	29.0	22.0	1.7	0.0		46	32						105.2	18.3	
11814	SAMPLE #5	N/R	CL	44.0	32.4	22.0	1.6	0.0		45	32						105.7	17.0	
11815	TP-105	0.0'- 4.0'	CL	48.4	28.3	20.8	2.5	0.0		46	31		22.1				6		
11816	TP-105	4.0'- 9.0'	CL	34.1	39.9	23.7	2.3	0.0		34	20								



PARTICLE SIZE DISTRIBUTION TEST REPORT 100 90 80 70 FINER 09 PERCENT 04 04 30 20 10 0.01 0.001 10.0 200 100 1.0 GRAIN SIZE - mm

	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
•	8	0.0	2.5	22.1	28.5	46.9	CL	46	32
			The state of the state of					16 16	
-	_					GIVEN THE WAR		1	33377

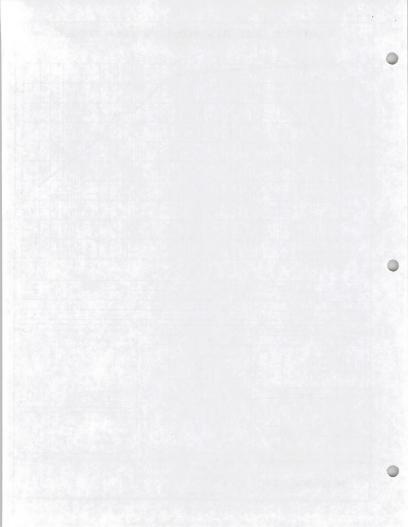
SIEVE	PERCENT FINER	SIEVE	PERCE	NT FINER	Sample information:
inches size	•	number	•		• Sample #3
1.5 0.75 0.375	100.0 98.9 98.6 98.0 GRAIN SIZE	4 8 16 30 50 100 200	97.5 96.8 96.2 95.3 92.5 85.0 75.4		Lean clay with sand
D ₆₀ D ₃₀ D ₁₀	COEFFICIENTS				Remarks: Sampled by client Lab# 11812 Nat. Moist. 17.7%

MSE-HKM, INC.

Project No.: 11M145.115

Project: U.S.B.R.- Anita Dam

Date: 04-28-97



______ GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 8 Date: 04-28-97 _____ject No.: 11M145.115 Project: U.S.B.R .- Anita Dam Sample Data oumpto outu Location of Sample: Sample #3 Sample Description 1: Lean clay with sand Sample Description 2: USCS Class: CL Liquid limit: 46 Plasticity index: 32 ______ Notes Remarks: Sampled by client Lab# 11812 Nat. Moist. 17.7% Fig. No.: 1 Mechanical Analysis Data ______ Size, mm Percent finer Sieve 3 inches 76.20 100.0 1.5 inches 38.10 98.9 0.75 inches 19.05 98.6 9.53 98.0 0.375 inches 4.750 97.5 2.360 96.8 1.180 96.2 - 8 # 16 0.600 95.3 # 30 0.300 92.5 0.150 85.0 0.075 75.4 # 50 # 100 # 200

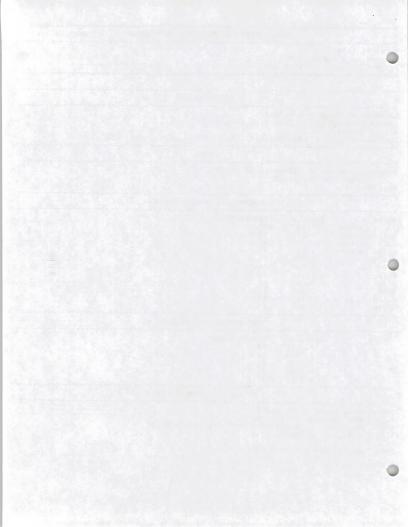
Hydrometer Analysis Data

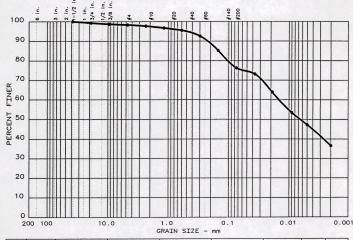
Size, mm Percent finer 0.0370 74.1 0.0190 62.0 0.0090 52.9 0.0050 46.9 0.0020 37.8

Fractional Components

Gravel/Sand based on #4 sieve Sand/Fines based on #200 sieve % + 3 in. = 0.0 % GRAVEL = 2.5 % SAND = 22.1 % SILT = 28.5 % CLAY = 46.9

D85= 0.15 D60= 0.017 D50= 0.007





	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	uscs	LL	PI
•	9	0.0	1.7	22.0	29.0	47.3	CL	46	32
_									

inches size	•		
1.5 0.75 0.375	100.0 99.3 98.7		
>	GR	AIN SI	ZE
D ₆₀ D ₃₀ D ₁₀			
\sim	COE	FFICIE	NTS
C _c			

SIEVE PERCENT FINER

SIEVE	PERC	PERCENT FINER				
size						
4 8 16 30 50 100 200	98.3 97.7 96.7 95.5 92.6 85.3 76.3					
				22		

Sample information:

• Sample #4 Lean clay with sand

Remarks:

Sampled by client

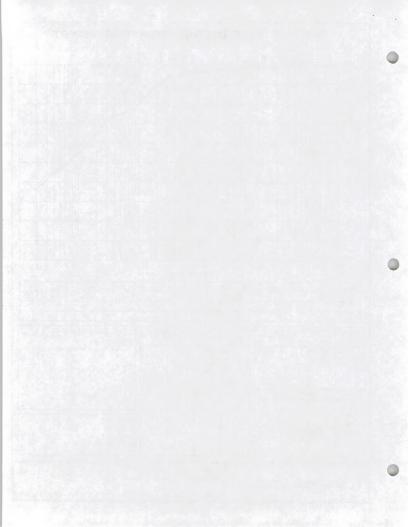
Lab# 11813 Nat. Maist. 17.1%

MSE-HKM, INC.

Project Na.: 11M145.115

Project: U.S.B.R.- Anita Dam

Date: 04-28-97



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Date: 04-28-97
```

oject No.: 11M145.115

Project: U.S.B.R. - Anita Dam _______

Sample Data

Location of Sample: Sample #4

Sample Description 1: Lean clay with sand

Sample Description 2:

USCS Class: CL Liquid limit: 46 Plasticity index: 32

Notes

Remarks: Sampled by client Lab# 11813

Nat. Moist. 17.1% Fig. No.: 2

Mechanical Analysis Data

Sieve		Size, mm	Percent finer	
1.5	inches	38.10	100.0	
0.75	inches	19.05	99.3	
0.375	inches	9.53	98.7	
# 4		4.750	98.3	
# 8		2.360	97.7	
1 6		1.180	96.7	
# 30		0.600	95.5	
# 50		0.300	92.6	
# 100		0.150	85.3	
# 200		0.075	76.3	
# 200		0.075	76.3	

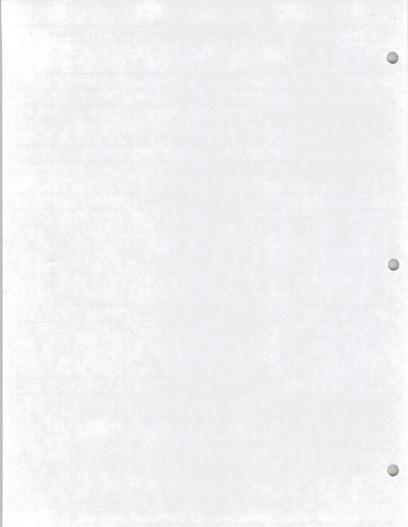
Hydrometer Analysis Data

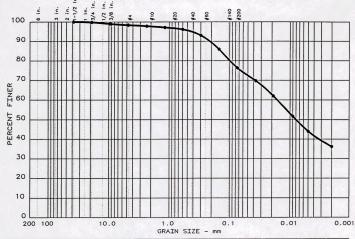
Size, mm	Percent finer	
0.0370	73.2	
0.0190	64.0	
0.0090	53.4	
0.0050	47.3	
0.0020	36.6	

Fractional Components

Gravel/Sand based on #4 sieve Sand/Fines based on #200 sieve % + 3 in. = 0.0 % GRAVEL = 1.7 % SAND = 22.0 % SILT = 29.0 % CLAY = 47.3

D85= 0.15 D60= 0.015 D50= 0.007





	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
•	10	0.0	1.6	22.0	32.4	44.0	CL	45	32
_					TANK A CANAL		Mrs - Service		

inches size	•		3.70	ı
1.5 0.75 0.375	100.0 99.8 99.0			
> <	GR	AIN SI	ZE	
D ₆₀ D ₃₀ D ₁₀				
> <	COE	FFICIE	NTS	
CCu				

PERCENT FINER

SIEVE

SIEVE	PERC	ENT FI	NER
number size	•	3 11 (2)	
4 8 16 30 50 100 200	98.4 97.9 97.2 96.2 93.1 85.9 76.4		
	7.7		

Sample information:
• Sample #5

Lean clay with sand

Remarks:

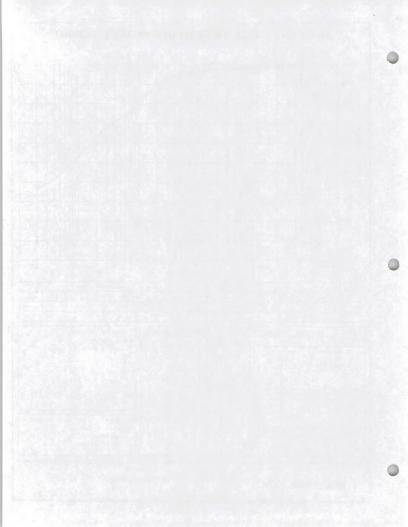
Sampled by client Lab #11814

MSE-HKM, INC.

Project No.: 11M145.115

Project: U.S.B.R. - Anita Dam

Date: 04-28-97



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Date: 04-28-97
```

roject No.: 11M145.115

Project: U.S.B.R. - Anita Dam

Sample Data ______

Location of Sample: Sample #5

Sample Description 1: Lean clay with sand

Sample Description 2:

USCS Class: CL Liquid limit: 45 Plasticity index: 32

Notes

Remarks: Sampled by client Lab #11814

Fig. No.: 3

Mechanical Analysis Data

S	Leve		Size,	mm	Percent	: fin
1.	. 5	inches	38.10)	100.0	
0.	75	inches	19.05	5	99.8	
0.	375	inches	9.53	3	99.0	
#	4		4.75	50	98.4	
#	8		2.36	50	97.9	
	16		1.18	30	97.2	
#	30		0.60	00	96.2	
#	50		0.30	00	93.1	
#	100		0.15	50	85.9	
#	200		0.07	75	76.4	

Hydrometer Analysis Data

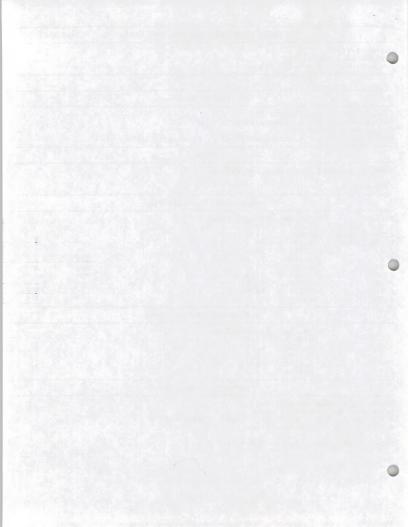
Size, mm	Percent finer	
0.0370	69.8	
0.0190	62.1	
0.0090	51.7	
0.0050	44.0	
0.0020	36.2	

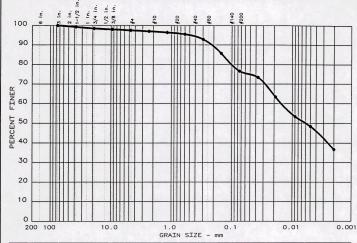
Fractional Components

Gravel/Sand based on #4 sieve Sand/Fines based on #200 sieve % + 3 in. = 0.0 % GRAVEL = 1.6 % SAND = 22.0

% SILT = 32.4 % CLAY = 44.0

D85= 0.14 D60= 0.016 D50= 0.008





	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
•	11	0.0	2.5	20.8	28.3	48.4	CL	46	31
Г				- mistrat			5-16-5-16-5-16		
			11/10/19/51 7			XI Talan Place and the			

SIEVE	PERCENT FINER	SIEVE	PERC	ENT FI	NER
inches	•	number size	•		
3 1.5 0.75 0.375	100.0 99.3 98.5 98.0	4 8 16 30 50 100	97.5 97.0 96.4 95.5 92.9 85.7		
\sim	GRAIN SIZE	200	76.7		
D ₆₀ D ₃₀ D ₁₀					
\sim	COEFFICIENTS				
C c					

Sample information: • TP-105 @ 0.0' - 4.0'

• TP-105 @ 0.0' - 4.0 Lean clay with sand

Remarks:

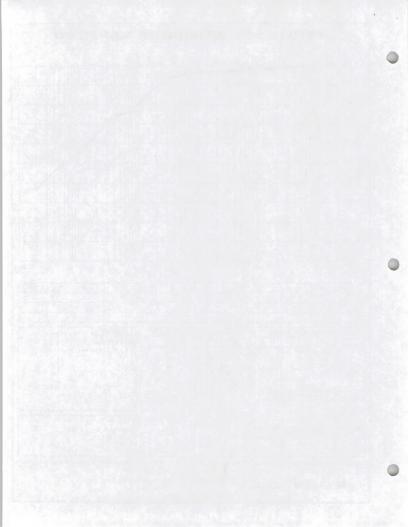
Sampled by client Lab# 11815

MSE-HKM, INC.

Project No.: 11M145.115

Project: U.S.B.R.- Anita Dam

Date: 04-28-97



Date: 04-28-97

roject No.: 11M145.115

Project: U.S.B.R. - Anita Dam

Sample Data

Location of Sample: TP-105 @ 0.0' - 4.0' Sample Description 1: Lean clay with sand

Sample Description 2:

USCS Class: CL Liquid limit: 46 Plasticity index: 31

Notes

Remarks: Sampled by client Lab# 11815

Sieve Size, mm Percent finer

Fig. No.: 4

Mechanical Analysis Data

3	inches	76.20	100.0
1.5	inches	38.10	99.3
0.75	inches	19.05	98.5
0.375	inches	9.53	98.0
# 4		4.750	97.5
8		2.360	97.0
# 16		1.180	96.4
# 30		0.600	95.5
# 50		0.300	92.9
# 100		0.150	85.7
# 200		0.075	76.7

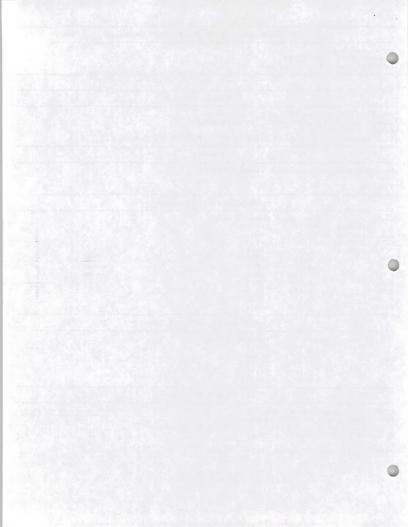
Hydrometer Analysis Data

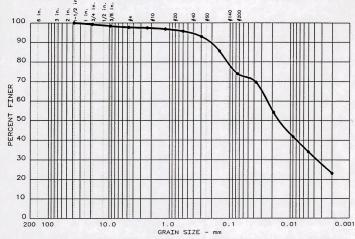
Size, mm	Percent	finer
0.0370	73.5	
0.0190	63.5	
0.0090	53.4	
0.0050	48.4	
0.0020	36 7	

Fractional Components

Gravel/Sand based on #4 sieve Sand/Fines based on #200 sieve % + 3 in. = 0.0 % GRAVEL = 2.5 % SAND = 20.8 % SILT = 28.3 % CLAY = 48.4

D85= 0.14 D60= 0.015 D50= 0.006





	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
•	12	0.0	2.3	23.7	39.9	34.1	CL	34	20

inches size	•			
1.5 0.75 0.375	100.0 99.3 98.4			
> <	GR	AIN SI	ZE	
D ₆₀ D ₃₀ D ₁₀	0.0035			
> <	COEFFICIENTS			
Ccu				

SIEVE PERCENT FINER

SIEVE	PERC	ENT	FINE	R
number size	•	1		
4 8 16 30 50 100 200	97.7 97.4 96.8 95.7 93.0 85.6 74.0			

Sample	informa	tion:
• TP-105	@ 4.0'	- 9.0
Lean cl	ay with	sand

Remarks:

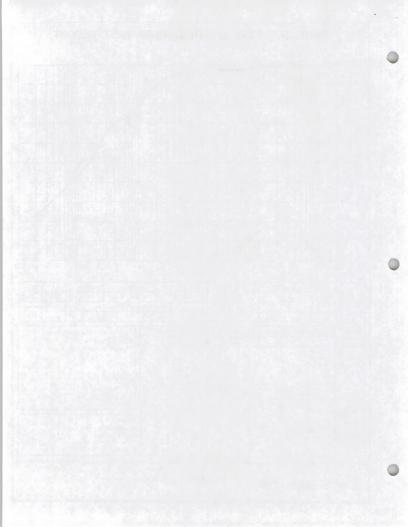
Sampled by client Lab# 11816

MSE-HKM, INC.

Project No.: 11M145.115

Project: U.S.B.R.- Anita Dam

Date: 04-28-97



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Date: 04-28-97
```

roject No.: 11M145.115

Project: U.S.B.R. - Anita Dam

Sample Data

Location of Sample: TP-105 @ 4.0' - 9.0' Sample Description 1: Lean clay with sand

Sample Description 2:

USCS Class: CL Liquid limit: 34 Plasticity index: 20 _____

Notes

Remarks: Sampled by client Lab# 11816

Fig. No.: 5

Mechanical Analysis Data

Sieve		Size, mm	Percent	finer
1.5	inches	38.10	100.0	
0.75	inches	19.05	99.3	
0.375	inches	9.53	98.4	
# 4		4.750	97.7	
# 8		2.360	97.4	
16		1.180	96.8	
# 30		0.600	95.7	
# 50		0.300	93.0	
# 100		0.150	85.6	
# 200		0.075	74.0	

Hydrometer Analysis Data ______

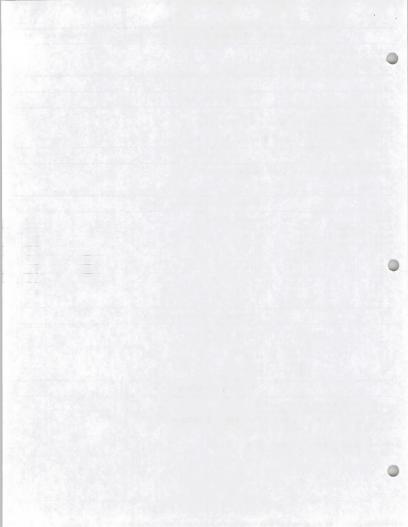
Size, mm	Percent	finer
0.0370	69.7	
0.0190	54.2	
0.0090	41.8	
0.0050	34.1	
0.0020	23.2	

Fractional Components

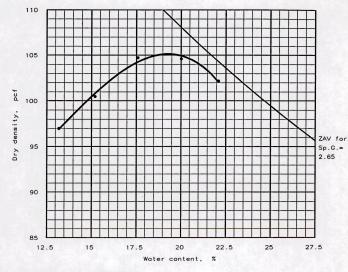
Gravel/Sand based on #4 sieve Sand/Fines based on #200 sieve

% + 3 in. = 0.0 % GRAVEL = 2.3 % SAND = 23.7 % SILT = 39.9 % CLAY = 34.1

D85= 0.14 D60= 0.024 D50= 0.015 D30= 0.0035



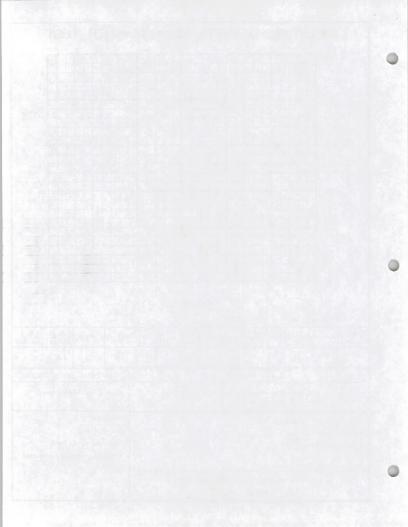
MOISTURE-DENSITY RELATIONSHIP TEST



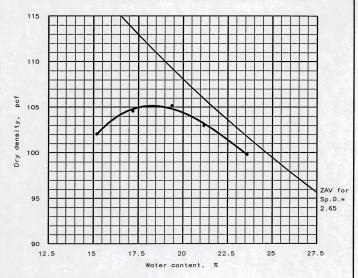
Test specification: USBR 5500

Elev/	Classification		Nat.	Sp.G.		PI	% >	% <
Depth	USCS	AASHT0	Moist.	ър. С.			No.4	No. 200
	CL		17.7 %	N/T	46	32	2.5 %	75.4 %

	CL		17.7 %	N/T	46	32	2.5 %	75.4 %		
	TI	MA	MATERIAL DESCRIPTION							
	Maximum dry Optimum mois	Lean	Lean Clay with Sand							
Projec	et No.: 11M145.11	5			Rema	Remarks:				
Projec	ct: Anita Dam				Lab	Lab # 11812				
Locat	ion: Sample #3				Sampled by Client					
147		Spec	Specific gravity assumed							
Date:	04-24-97									
	MOISTURE-DENS	SITY RELATIONSHIP	TEST							
	MSE-	Fig. No. 6								



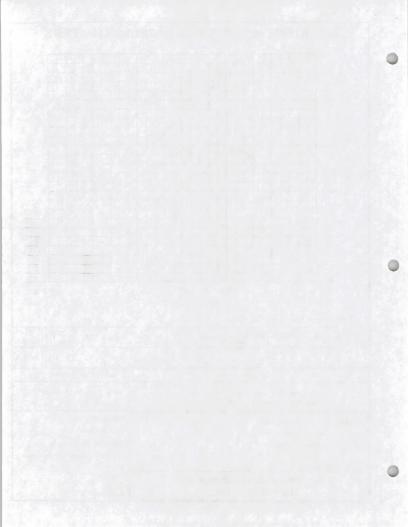
MOISTURE-DENSITY RELATIONSHIP TEST



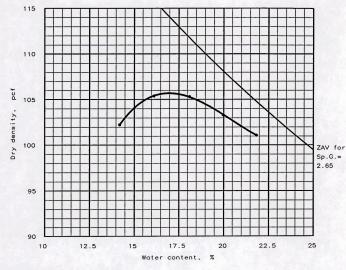
Test specification: USBR 5500

Elev/	Classification		Nat.	Sp.G.	LL	PI	% >	% <
Depth	USCS	AASHT0	Moist.	эр.б.		-	No.4	No.200
4 4	CL		17.1 %	N/T	46	32	1.7 %	76.3 %

CL			17.1 %	N/T	46	32	1.7 %	76.3 %		
	MA	MATERIAL DESCRIPTION								
Maximum dry density = 105.2 pcf Optimum moisture = 18.3 %						Lean Clay with Sand				
Project No.: 11M145.115					Remarks:					
Project: Anita Dam Location: Sample #4					Sampled by Client Specific gravity assumed					
Date: 04-24-97					Spec	ific gr	dvity d	ssumed		
MOIST		RELATIONSHI	P TEST		Fig.	No. 7				



MOISTURE-DENSITY RELATIONSHIP TEST

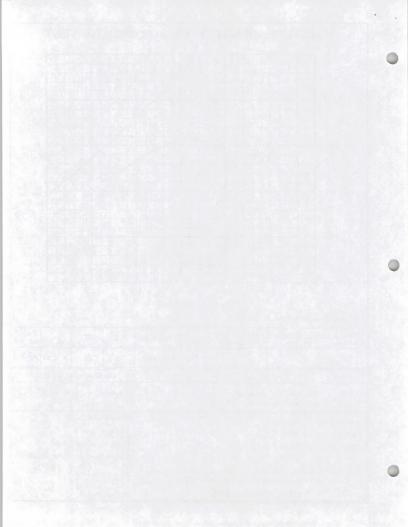


Test specification: USBR 5500

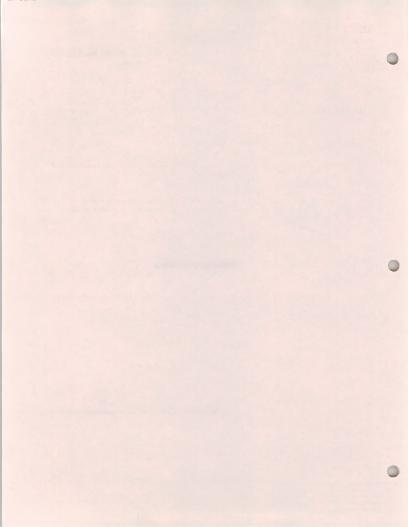
Elev/	Classification		Nat.	Sp.G.	LL	PI	% >	% <
Depth	USCS	AASHT0	Moist.	эр.б.		'-	No.4	No.200
	01		N/T %	N/T	45	32	1.6 %	76.4 %
	CL		14/1 %	147 1	45	32	1.0 %	70.4 %

CL	1	I/T %	N/T	45	32	1.6 %	76.4 %
TE	МА	MATERIAL DESCRIPTION					
Maximum dry Optimum mois	Lean Clay with Sand						
Project No.: 11M145.11 Project: Anita Dam Location: Sample #5		Remarks: Lab # 11814 Sampled by Client Specific gravity assumed					
Date: 04-24-97	ITY RELATIONSHIP T	EST					

MSE-HKM, INC.



DISPERSIVE CLAY TESTS



Maxim

600 South 25th Street O Box 30615 ogs, MT 59107 .6) 248-9161 FAX (406) 248-9282

TECHNICAL REPORT

REPORT TO: ATTN: GREG BERGUM

BUREAU OF LAND MANAGEMENT 111 GARRYOWEN ROAD MILES CITY, MT 59301 DATE: JOB NUMBER: April 18, 1997

SHEET:

5509702120

REPORT OF: Laboratory Testing - Anita Dam

SAMPLE IDENTIFICATION:

On April 14, 1997, we received two soil samples from the subject site with instructions to perform a pinhole dispersion test and a crumb test on each sample. The tests were prepared and performed in general accordance with the test procedures summarized below.

Test

Standard

Pinhole Dispersion Test

ASTM D4647-87 (method B)

Crumb Test

Corp of Engineers Manual EM-110-2-1906 Appendix XIII

The test results are included on the attached table. If you have any questions regarding this report or if we can be of any further service, please us.

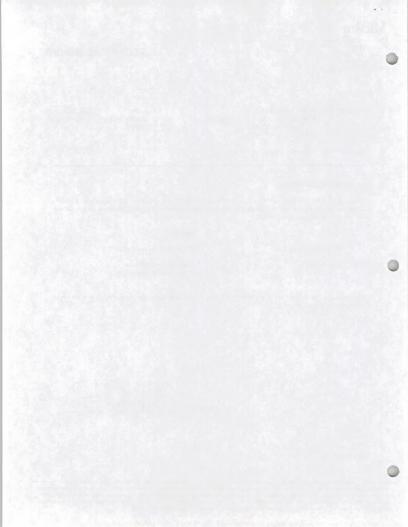
Reviewed by Tuk Sull

Attachment

ba

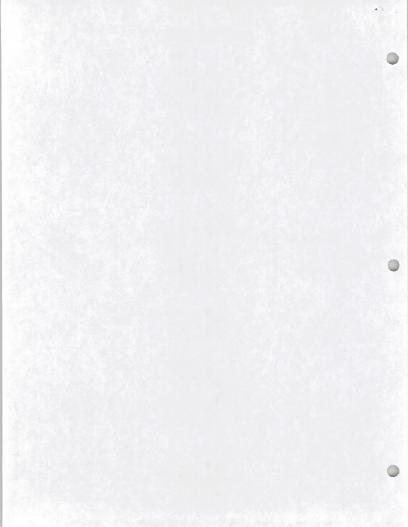
n\geotech\2120-2.rpt

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.



ANITA DAM TEST RESULTS

Sample Identification	Remolded Dry Density(pcf)	Dry Content(%)	Hydraulic Head(inches)	Final Cloudiness of Fluid	Final Pinhole Diameter(mm)	Dispersive Classification	Crumb Test Classification
TP 101 1.5'-4.0	0' 113.0	8.7	7	medium to dark	2.0	Slighty Dispersive, SD	Possible Dispersion Problem
No. 3	95.4	19.2	7	medium to dark	2.5	Slighty Dispersive, SD	Definite Dispersion Problem



Maxim

600 South 25th Street O Box 30615 Illings, MT 59107 .406) 248-9161 FAX (406) 248-9282

TECHNICAL REPORT

REPORT TO: ATTN: GREG BERGUM

U.S. DEPARTMENT OF INTERIOR BUREAU OF LAND MANAGEMENT

P O BOX 36800

BILLINGS MT 59107-6800

DATE: JOB NUMBER: April 18, 1997

JOB NUMBER: SHEET:

93-925-1 1 of 3 040443

REPORT OF: Soil Analysis - Anita Dam

SAMPLE IDENTIFICATION:

On April 14, 1997, these soil samples (laboratory numbers 182747 and 182748) were received in our laboratory for analysis. Tests were conducted in accordance with U.S. Department of Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils".

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist.

The results of the analyses are shown on the following pages.

RECEIVED

ASR 2.2 137

LEWISTONN, NONTARA

Reviewed by Katilla A JA

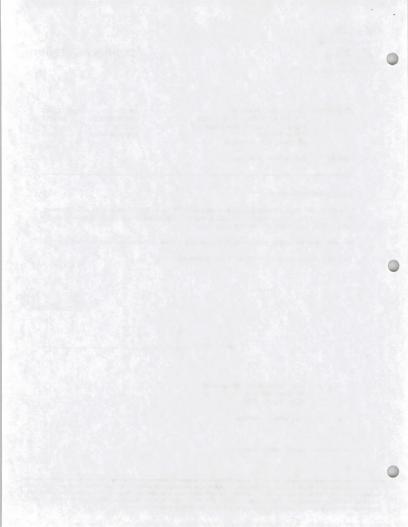
cc:

USDI Bureau of Land Management 111 Garryowen Road Miles City, MT 59301

Nick Lewallen - Billings

Attachments: Sample Receipt Checklist

caj



Page 2

Client Name: USDI BUREAU OF LAND MANAGEMENT - MILES CITY

Project No.: 93-925-1 Laboratory No.: 182747

Sample Name: TP 101 1.5-4.0
Sample Date: NONE GIVEN
Collected by: NONE GIVEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

	MEASURED	METHOD DATE
PARAMETER	VALUE	NUMBER ANALYZED

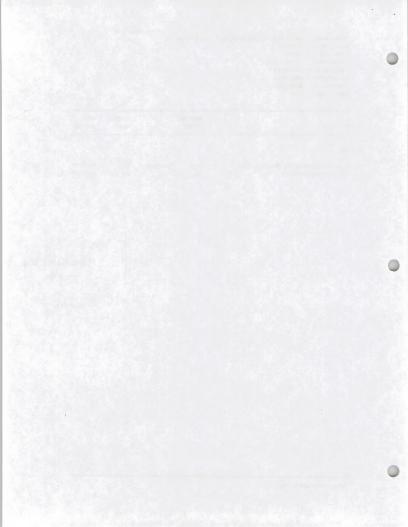
SOIL

 Electrical Conductivity Saturated Pcste
 7.40
 mmhos/cm
 3a
 04/16/97

 Sodium Absorption Ratio
 14.4
 20b
 04/16/97

RECEIVED

LENGTO S 0 197
LENGTO S 0 1 PAR
LENGTO S 0 PAR
LENG



Page

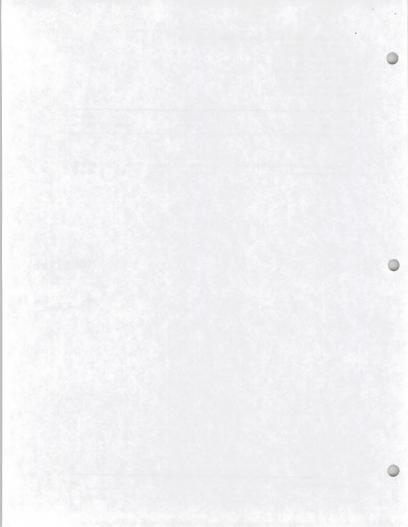
Client Name: USDI BUREAU OF LAND MANAGEMENT - MILES CITY

Project No.: 93-925-1
Laboratory No.: 182748
Sample Name: NO. 3
Sample Date: NOME GIVEN
Collected by: NOME GIVEN
Time Sampled: NOME GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
SOIL				
Electrical Conductivity Saturated Paste	9.03	mmh4s/cm	3a	04/16/97
Sodium Absorption Ratio	19.2		20b	04/16/97

RECEIVED



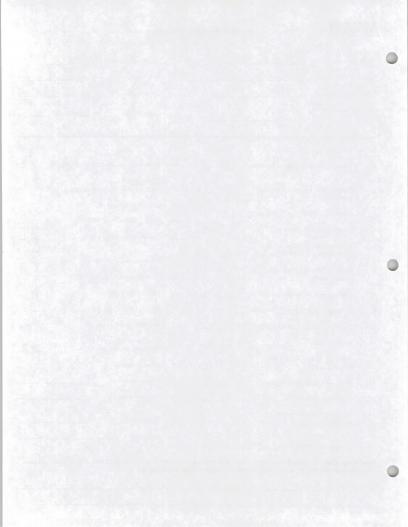




COMMENTS:

SAMPLE RECEIPT CHECKLIST

rojec	atory number(s) 172747-48	-		Carrier name April dele	aero
Check by:	list completed Initials Da	/ <i>4</i>		Sample Type	5
		YES NO			YES N
	Shipping container in good condition?	NH	16.	All samples rec'd within holding time?	10
	Custody seals present on shipping container?	11 4	17.	Preservation pH check performed by:	, 1
		14 1	18.	Metals bottle(s) pH <2?	4
	Condition: Intact Broken		19.	Nutrient bottle(s) pH <2?	-/
	Chain of custody present?		20.	Cyanide bottle(s) pH >12?	1
	Chain of custody signed when relinquished and received?	NA	21.	Sulfide bottle(s) pH >9?	_
i.	Chain of custody agrees with sample labels?	NA	22.	Oil & grease bottle(s) pH <2?	- /
	Custody seals on sample bottles?	- V	23.	TOC bottle(s) pH <2?	1
	Condition: Intact Broken		24.	DRO/418.1 bottle(s) pH ≤2?	-
	Samples in proper container/bottle?	V _	25.	Phenolics bottle(s) pH <2?	_4
10.	Samples intact?	<u>~</u> _	26.	Volatiles (VOA) pH <2? (VOA pH checked by analyst)	W
1.	Sufficient sample volume for indicated test?	4-	27.	Client contacted?	
2.	VOA vials have zero headspace?	44	28.	Person contacted	
3.	Trip Blank received?	- 1	29.	Date contacted	
14.	Ice/Frozen Blue Ice present in shipping container? (circle one)	N'A	30.	Contacted by	
	Container temperature 1 2		31.	Regarding?	



NORTHERN TESTING LABORATORIES, INC.

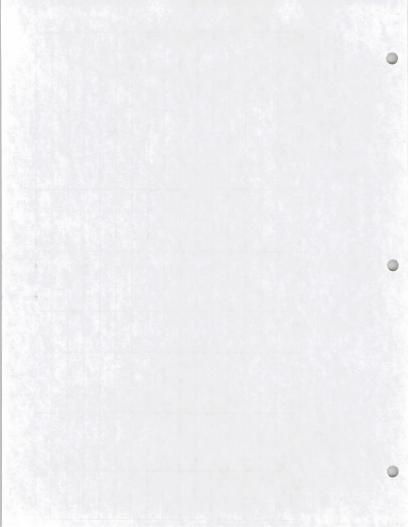
SUMMARY OF ENGINEERING PROPERTIES TESTS

Project Bureau of Land management

Anita Dam

Job No. 5509702120
Date Rec'd in Lab
Date Tests Complete

Industrial III	1 00111 1101 5	DEPTH, FEET	LOCATION	TYPE SAMPLE	TYPE SOIL	TESTS TO PERFORM & INSTRUCTIONS
SAMPLE NO.	DRILL HOLE		LUCATION	TITE SAMELE	TIPE SUIL	
182747		1.5-4.0				Sedium Absorption (Total Dissolut Carts)
48	No. 3					of - ECE - RITH
			100			Sidium Absorption (Total Dissilud Sarts) Ect = Telliph 48 hr. Turn demod)
V.C.	1					
1149						
						Results to Grey Bergum
						Joed Frank of Jewell Joed War of Control of Control of the Note of
						GG GN John
			22.5			great 97 les evol
						Deed & MIM & Jour Det
						y often
						Ror
						(LC



Maxim

600 South 25th Street P O Box 30615 Billings, MT 59107 (406) 248-9161 FAX (406) 248-9282

97 APR 29 " 8 F2

TECHNICAL REPORT

REPORT TO: ATTN: GREG BERGUM BUREAU OF LAND MANAGEMENT 111 GARRYOWEN ROAD MILES CITY, MT 59301

DATE: JOB NUMBER: SHEET:

April 24, 1997 5509702120 1 of 1

REPORT OF: Laboratory Testing - Anita Dam

WHIANS

SAMPLE IDENTIFICATION:

On April 21, 1997, we received a soil sample from the subject project with instructions to perform a pinhole dispersion test and crumb test. The tests were prepared and performed in general accordance with the test procedures summarized below.

TEST

Crumb Test

Pinhole Dispersion Test

STANDARD

ASTM D4647-87(method B) Corp of Engineers Manual EM-110-2-1906 Appendix XIII

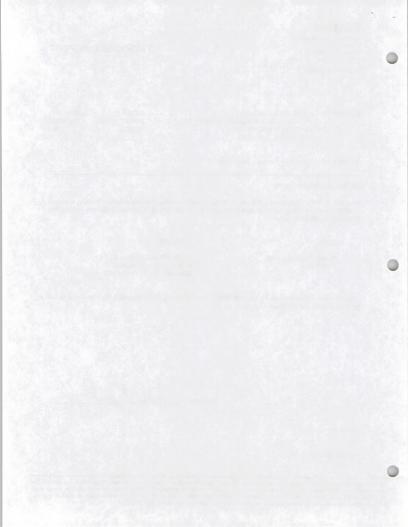
The test results are included on the attached table. If you have any questions regarding this report or if we can be of any further service, please contact us.

Reviewed by Michel & Jewill

Attachments

n\geotech\anita.dam

As a mutual protection to clients, the public and ourselves, all reports are submitted es the confidential property of our clients end authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written epprovel of the leboretory. Semples will be disposed of efter testing is completed unless other errengements ere egreed to in writing.

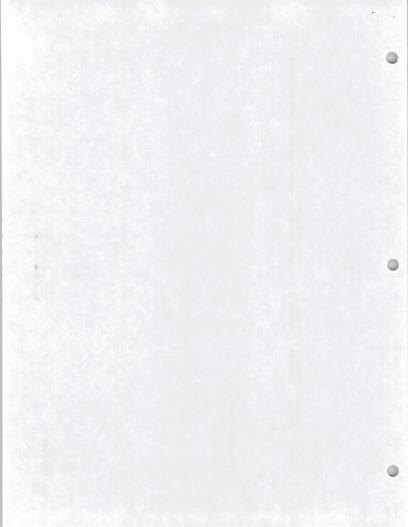


ANITA DAM TEST DATA SUMMARY

TEST DATA

Sample Identification	Remolded Dry Density(pcf)	Moisture Content (%)*	Hydraulic Head(inches)	Final Cloudiness	Final Diameter of Pinhole(mm)	Dispersive Classification	Crumb Test Classification
No. 4	104.8	17.7	-5	Slight to Medium	3.5	Slightly to Moderately Dispersive-SD	Definite Dispersion Problem

^{*} As Received Moisture Content



Maxim

600 South 25th Street P O Box 30615 Billings, MT 59107 (406) 248-9161 FAX (406) 248-9282



TECHNICAL REPORT

REPORT TO: ATTN: GREG BERGUM U.S. DEPARTMENT OF INTERIOR

> BUREAU OF LAND MANAGEMENT P O BOX 36800

BILLINGS MT 59107-6800

Revised: May 16 1997* DATE: April 18, 1997

IOB NUMBER: 93-925-1 SHEET: 1 of 3

INVOICE NO .: 040443

SAMPLE IDENTIFICATION:

REPORT OF: Soil Analysis - Anita Dam

On April 14, 1997, these soil samples (laboratory numbers 182747 and 182748) were received in our laboratory for analysis. Tests were conducted in accordance with U.S. Department of Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils".

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist.

The results of the analyses are shown on the following pages.

Footnote: (1) The total dissolved salt concentration is calculated from the electrical conductivity. The relationship between conductivity and soluble salts is approximate due to difference in solutes, solute conductivities, and equivalent weights.

*Calcium, magnesium, sodium and total dissolved salts data added to the report.

Reviewed by Denur Jun.

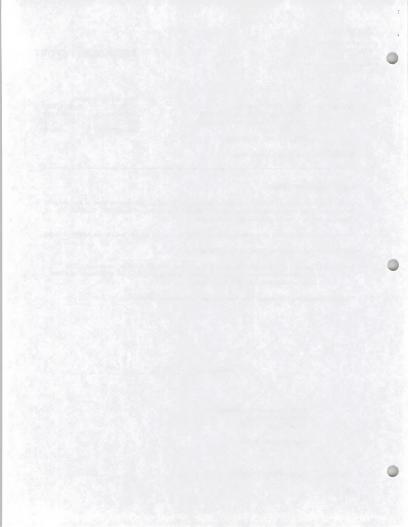
cc:

USDI Bureau of Land Management 111 Garryowen Road Miles City, MT 59301

Nick Lewallen - Billings

Sample Receipt Checklist Attachments:

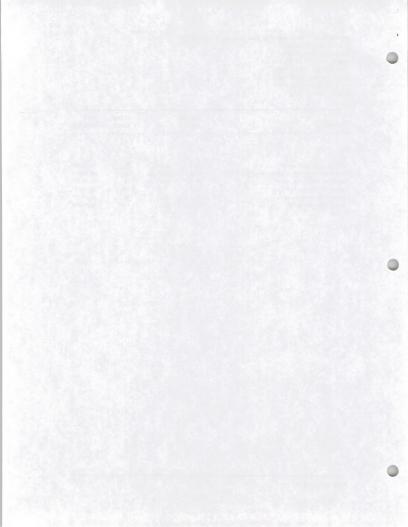
caj



Client Name: USDI BUREAU OF LAND MANAGEMENT - MILES CITY

Project No.: 93-925-1
Laboratory No.: 182747
Sample Name: TP 101 1.5-4.0
Sample Date: NOME GIVEN
Collected by: NOME GIVEN
Time Sampled: NOME GIVEN
Sample Type: SOIL

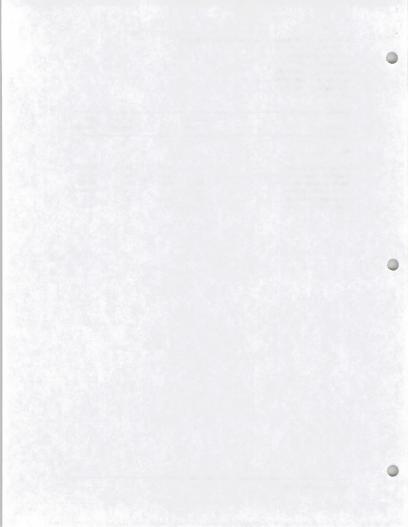
	MEASURED	YOU L	METHOD	DATE	
PARAMETER	VALUE		NUMBER	ANALYZED	
SOIL					
Calcium saturated paste	23.2	meq/l	3a	04/15/97	
Electrical Conductivity Saturated Paste	7.40	mmhos/cm	3a	04/16/97	
Magnesium saturated paste	19.7	meq/l	3a	04/15/97	
Sodium Absorption Ratio	14.4		20b	04/16/97	
Sodium saturated paste	69.2	meq/l	3a	04/15/97	
Total Dissolved Salts	4740 (1)	mg/l	1.20	04/16/97	



Client Name: USDI BUREAU OF LAND MANAGEMENT - MILES CITY

Project No.: 93-925-1
Laboratory No.: 182748
Sample Name: No. 3
Sample Date: NONE GIVEN
Collected by: NONE GIVEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

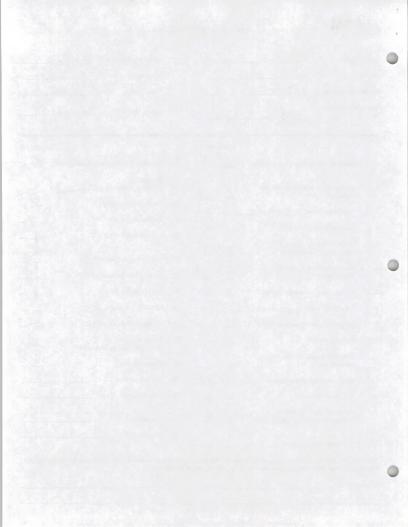
PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
SOIL				
Calcium saturated paste	23.2	meq/l	3a	04/15/97
Electrical Conductivity Saturated Paste	9.03	mmhos/cm	3a	04/16/97
Magnesium saturated paste	23.0	meq/l	3a	04/15/97
Sodium Absorption Ratio	19.2		20b	04/16/97
Sodium saturated paste	92.4	meq/l	3a	04/15/97
Total Dissolved Salts	5780 (1)	mg/l	1.20	04/16/97





SAMPLE RECEIPT CHECKLIST

Labora	atory number(s) 182747-48			Carrier name Sauddele	uero
Check by:	list completed Initials / Da	14		Sample Type	0
		YES NO			YES N
1.	Shipping container in good condition?	NH	16.	All samples rec'd within holding time?	N
2.	Custody seals present on shipping container?	NA	17.	Preservation pH check performed by:	1)
3.	Condition: Intact Broken	T T	18.	Metals bottle(s) pH <2?	W
4.	Chain of custody present?	V	19.	Nutrient bottle(s) pH <2?	-/-
5.	Chain of custody signed when		20.	Cyanide bottle(s) pH >12?	+-
	relinquished and received?	N H	21.	Sulfide bottle(s) pH >9?	1
6.	Chain of custody agrees with sample labels?	NA	22.	Oil & grease bottle(s) pH <2?	=
7.	Custody seals on sample bottles?	- V	23.	TOC bottle(s) pH <2?	-/-
8.	Condition: Intact Broken	_	24.	DRO/418.1 bottle(s) pH <2?	->
9.	Samples in proper container/bottle?	V _	25.	Phenolics bottle(s) pH <2?	4
10.	Samples intact?	¥ -	26.	Volatiles (VOA) pH <2? (VOA pH checked by analyst)	M
11.	Sufficient sample volume for indicated test?	V -	27.	Client contacted?	
12.	VOA vials have zero headspace?	NA	28.	Person contacted	
13.	Trip Blank received?	- ×	29.	Date contacted	
14.	Ice/Frozen Blue Ice present in shipping container? (circle one)	NA	30.	Contacted by	
15.	Container temperature 1 2	3	31.	Regarding?	
	Samples may be affected when not transport contact the lab if you have concerns about	orted at the temper			selecte



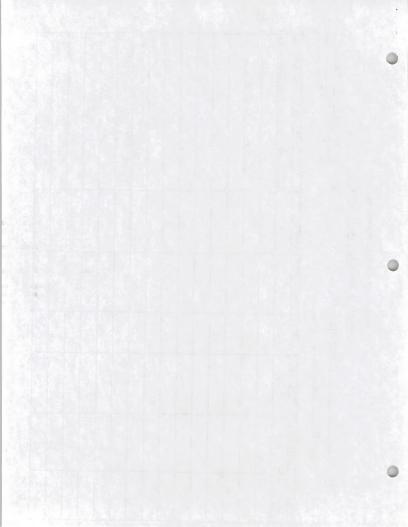
NORTHERN TESTING LABORATORIES, INC.

SUMMARY OF ENGINEERING PROPERTIES TESTS

Project_	Bureau	of Land	management
		Dam	

Job No. SS09702120
Date Rec'd in Lab
Date Tests Complete_____

1 - AVEL 5 110	DRILL HOLE	DEPTH, FEET	LOCATION	TYPE SAMPLE	TYPE SOIL	TESTS TO PERFORM & INSTRUCTIONS
SAMPLE NO.		1.5-4.0	200/11/01/			Soffing About the State Dischard course
182747		1.5-7.0				Tale Tale
48	No. 3					The state of the s
						Hohr. Turn drawad
1/1						
- 6114			F 5%			
91						Results to Grey Bergum
						Co in Solew
				All Maria		Qued to the Notarion of the Royal Control of the Royal to Notarion of the Royal of
						Record willing for the party of the
						The stell
						a Rov
		100				(C
	2.5					
					1	1



Maxim 600 South 25th Street P O Box 30615 Billings, MT 5910 (406) 248-9161

FAX (406) 248-9282

97 HAY 19

REPORT TO: ATTN: GREG BERGUM

U.S. DEPARTMENT OF INTERIOR BUREAU OF LAND MANAGEMENT

P O BOX 36800

BILLINGS MT 59107-6800

REPORT OF: Soil Analysis - Anita Dam

OFFICIAL FILE COPY WW 23'97 TECHNICAL REPORT STAG Y MARE INFO. COPY TO: INITIAL DATE DATE: May 8, 1997 IOB NUMBER CLASSIFICATION 25-1 SHEET: PROJECT INVOICE NO. CONTROL NO.

FOLDER I.D

SAMPLE IDENTIFICATION:

On April 21, 1997, this soil sample (laboratory number 182953) was received in our laboratory for analysis. Tests were conducted in accordance with U.S. Department of Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils and "Western States Laboratory Proficiency Testing Program, Soil & Plant Analytical Methods", 1996 Version 3.0.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist. Chain of custody documentation is enclosed.

The results of the analyses are shown on the following page.

Footnote: (1) The total dissolved salt concentration is calculated from the electrical conductivity. The relationship between conductivity and soluble salts is approximate due to difference in solutes, solute conductivities, and equivalent weights.

Kathlen A.

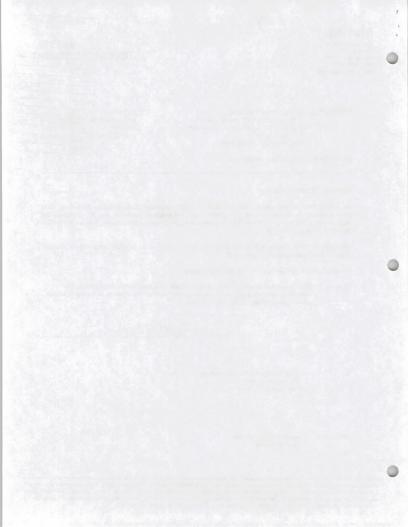
cc:

USDI Bureau of Land Management 111 Garryowen Road Miles City, MT 59301

Attachments:

Sample Receipt Checklist Chain of Custody

cai



Client Name: USD: - REAU OF LAND MANAGEMENT - MILES CITY

Project No.: 93-925-1 Laboratory No.: 182953

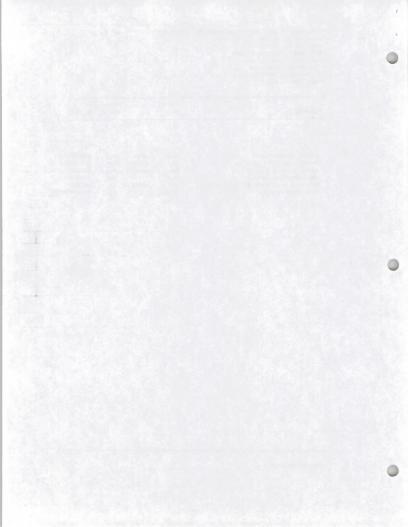
Sample Name: ANITA #4 PINHOLE Sample Date: NONE GIVEN Collected by: NONE GIVEN Time Sampled: NONE GIVEN Sample Type: SOIL

PINHOLE EN EN

	MEASURED	METHOD	DATE
PARAMETER	VALUE	NUMBER	ANALYZED

SOIL

Calcium saturated paste	32.2	meq/l	3a	05/05/97
Magnesium saturated paste	29.6	meq/l	3a	05/05/97
Sodium saturated paste	140	meq/l	3a	05/05/97
Sodium Absorption Ratio	25.2		20b	05/05/97
Electrical Conductivity Saturated Paste	14.1	mmhos/cm	3a	05/02/97
Total Dissolved Salts	9020(1)	mg/l	51.20	05/02/97



CHAIN OF CUSTODY RECORD

DAM -

Axita Project or Site Name Project Number

Sampler Name (Printed)

600 South 25th Street Billings, Montana 59101 Phone (406) 248-9161 • Fax (406) 248-9282 93-975-1

Greg Bergum

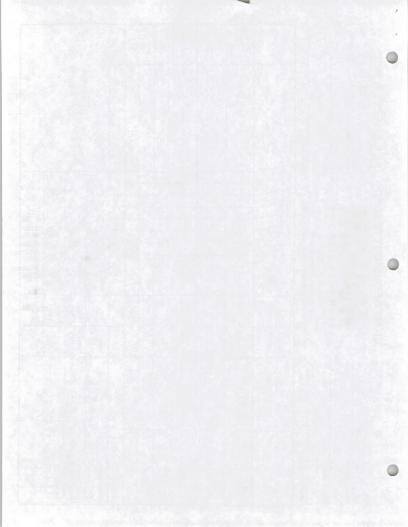
Contact Name

BLM (503) 226-1611

Address

Sampler Signature

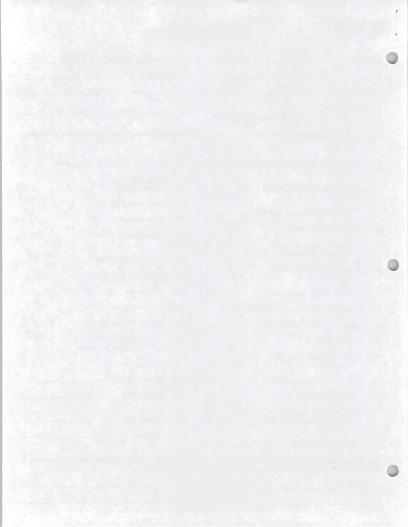
						2	ANALYSIS	REQUIF	ED		,
DATE	TIME	SAMPLE LOCATION OR DESCRIPTION	COMP OR GRAB	SAMPLE MATRIX	NO OT SCONTAINERS	545	1	11		NOTES	LAB NUMBER
NG	NG	anita #4	Reiho	le)							189953
Relinquished	by:		Date	Time	Received by:			7		Remarks:	
Refinquiched		Jockel Wales	4-21-9 Date 1-2191	11:22 Time //22/4	Received by:	Ultu	//	DCB.	lan		
Relinquished Relinquished	Acus	ther	Date 1/9/97 Date	Time ///2A Time	Received by:	luck	2	(2		



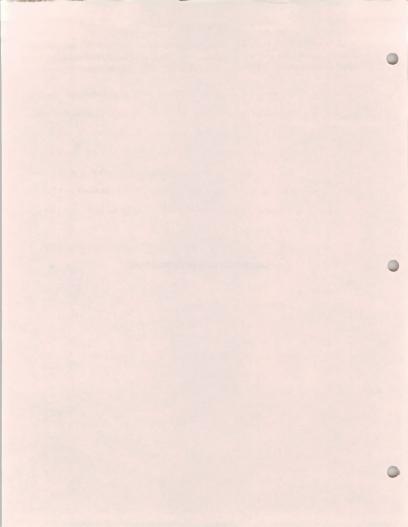


SAMPLE RECEIPT CHECKLIST

Project Labora	tory number(s) 187953		Received by Allengton Carrier name And deliners			
Checkl by:	ist completed Initials / Da	22te		Sample Type)	
	***	YES NO			YES NO	
1.	Shipping container in good condition?	11 4	16.	All samples rec'd within holding time?	<u> </u>	
2.	Custody seals present on shipping container?	NA	17.	Preservation pH check performed by:	1/4	
3.	Condition: Intact Broken		18.	Metals bottle(s) pH <2?	-7	
	Chain of custody present?	V	19.	Nutrient bottle(s) pH <2?	-/-	
			20.	Cyanide bottle(s) pH >12?	-/-	
	Chain of custody signed when relinquished and received?	<u> </u>	21.	Sulfide bottle(s) pH >9?		
5.	Chain of custody agrees with sample labels?	V	22.	Oil & grease bottle(s) pH <2?	_)_	
	Custody seals on sample bottles?	- K	23.	TOC bottle(s) pH <2?	_/_	
i.	Condition: Intact Broken	_ /	24.	DRO/418.1 bottle(s) pH <2?	5-	
).	Samples in proper container/bottle?		25.	Phenolics bottle(s) pH <2?	710	
10.	Samples intact?	∠ _	26.	Volatiles (VOA) pH <2? (VOA pH checked by analyst)	m	
11.	Sufficient sample volume for indicated test?	4	27.	Client contacted?		
12.	VOA vials have zero headspace?	NA	28.	Person contacted		
13.	Trip Blank received?	- <u>V</u>	29.	Date contacted		
14.	Ice/Frozen Blue Ice present in shipping container? (circle one)	NA	30.	Contacted by		
15.	Container temperature 1 2	3.	31.	Regarding?		







COMPUTATION SHEET

BY C.3. DATE S/15/97 PROJECT ANTA DAM	SHEET NO OF
CHKO. BY DATE FEATURE SOIL TESTS	ACTIVITY
OFFICE DETAIL _TDS / SAR / % SODIUM	2

LOUELL - PLOTS OF DATA FROM TOTAL DISSOLUED SALTS,

PERCENT SODIUM AND SODIUM ABSORBTION RATIO.

PLEASE NOTE THE AMOUNT OF POTASSIUM WAS NOT

MEASURED IN TALKING WITH KATAY AT MASIM

SHE SAID IT WAS USUALLY NEGLICABLE. IT DOES

LOOK AS THOUGH THE AMOUNT OF SODIUM PRESENT

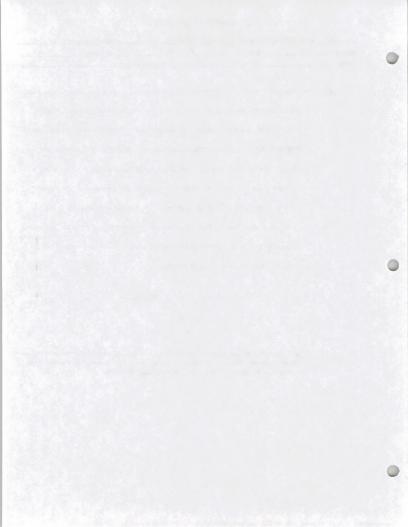
IS DIRECTLY RELATED TO "DISJOEASIBILITY" AS

INDICATED IN OUR PINHOLE TESTS. IT IS AMARING

HOW PLOTS FIT SAR POTENTIAL LINES. CALL ME IF

GREG.

LOVELL, I HAVE GIVEN MILL OFFICE FOR DATA EVER FOR LAST TED CHEMICAL ANALYSIS. I WILL FORWARD TO YOU AS SOON AS I RELEIVE THEM.



COMPUTATION SHEET

BY 68 DATE 3/15/97 PROJE	T ANTA DAN	7 SHI	EET NO OF
CHKD. BY DATE FEATU	RE SOIL TES	73 AC	TIVITY
OFFICE DETAIL	TDS/SAR/	1/0 500 um	
£ 10. 11	TP-101	SAMPLE .	<u>#4</u>
SAR= Na NO.5 (Ca+mg)	15 (14.4)	20 (19.2)*	25(25.2)
% 500/UM	62°/0	69%	69%
TOTAL DISSOLVED SALTS.	112.1 meal2	134.3 may)4	201,8 majo

* RESULTS AS TESTED BY MAXIM.

TP-101

$$SAZ = \frac{Nq}{N0.5 (ca+m_1)} = \frac{69.2}{N0.5 (23.2+197)} = \frac{69.2}{4.6} = 15.0 (144)$$

9/0 50DIUM = Na × 100 = 49.2 = 692 = 62% 10+10+64 69.2+23.2+19.7 1/2.1

TOTAL DISSOLVED GALTS: 1/2.1 MEG/L

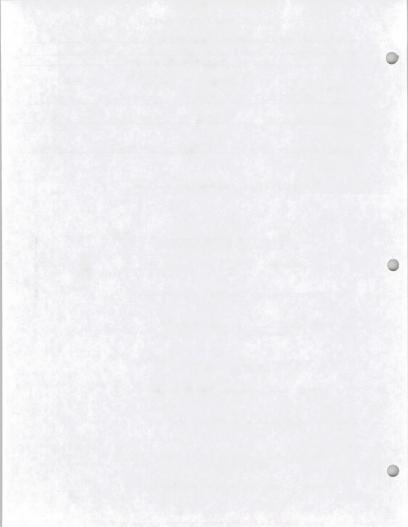
% SODWM = $\frac{924}{92.4 + 23.2 + 19.2}$ $\times 100 = 69\%$

TOTAL DISSOLUTO SALTS: 134.8 MEY/L

$$\frac{\#4}{\sqrt{0.5(37.2+27.6)}} = 25(25.2)$$

9/6 SODIUM = $140 \times 100 = 69\%$

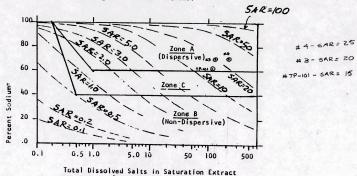
TOTAL DISSOLUED SALTS - 201.8 MEG/L



 $SAR = \frac{Na}{\sqrt{0.5(Ga+Mg)}}, all in meq./liter.$

- Hotes: 1) See description of Zones A, B and C in Text.
 - Relationship shown is valid only when eroding water is relatively pure.

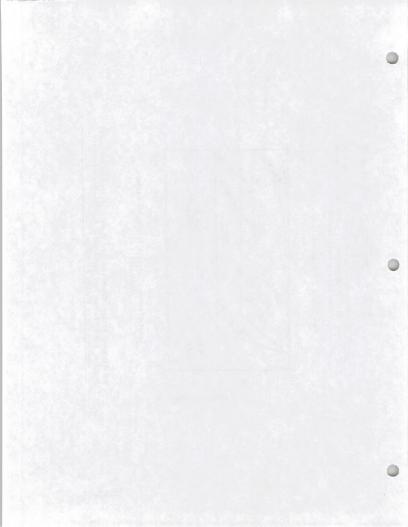
*See Figure 2 for definitions.



plationship Between Discounting of

(meg/liter) *

Relationship Between Dispersibility (Susceptibility to Colloidal Erosion) and Dissolved Pore Water Salts Based on Pinhole Tests and Caperience with Erosion in Nature



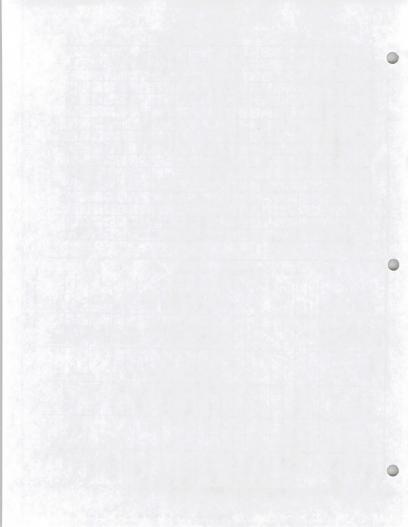
APPENDIX F
POST-FAILURE TROXLER DENSITY AND MOISTURE DATA



APR-13-1997

				W.D.	1		1 4	16	1770	crue	-										
STA	BR.	ELEV.	DEPIN	D.D.	9/0 m			. 17					-	_		6	1	<i>!</i>	7015	RAC	3900
5+45		2697 ¹⁰	6"	104=	14.5		9	~	10	716	1er	4_	Pec	47	oe	, \	5.4	5	ul	7 1	Rom
37.12			8"	1035	15.4		9	1.7	220	אמ											
)		2697	6"	1777		- C		00:	%:		No	10	4 :			~	× 1			-	
STSA		2697	6	197.3	16.8	- 14		01.		_	7-	30		22	-		í	-	7	-	7
			a"	109.4	16.2		′	P"	P-1		+	+	-		-	2	4	-		-	-
						- 100	7:	-		-	+-	╁			-	-		-+	-	-	4
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			6"	113.6	19.1	- 4.		2	7	1	1	10					2 4			71	
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	1.00		8"	113,3 95,4 1216	18.7	_1;			2.2	-	4}	Ł		-[-			-	-		
5+51		2691.98	6"	103.5	17.4	_ []		194	18		1)	"		-	_			_	_		\perp
1 4 2 3	347.752		8"	122,8	18.8	-	5	90	1.6		1	"			"			10			
3) 5+45		2L88 58	6"	114.3 95 A	19,2	7	11	a	1./	3			7:	12	2/5	240		1	-		701E
57.42			8"	97.4	199		13	9	0			T								.00	-
1		98	111	710.1	192			1	0			1-	Z	- /	w.	w	~			3 50	VE SA
5151		2688	6"	99.1	19	-	1	_	1 1	-	-	+-	1					-			MEN
			19	95.9	182	- :	1		76	-	+	+	-		/		724	رعرة	DE	an	
5+45		2690 20	6"	111.6 956 115.2	163		1	-	1.3		-	+	+-	1-4		\rightarrow	2/	18	יעם	240	1
			18"	09 3	173			9	19	1	-	6-	1	17		2		_		_	1_
5+51		2696	1."	719.1	183		113	90	4.1			3/16	14	1		(
5+51	ANTS	2010	8"	100.7	186	ーし	1		1.0		1 /	וכעוב	1.							T	1
B YKO	ACT AD		2 6"	100.6 118.8 98.8	196			723		05		-	1:11	50	1		23	B	50	12	N. S.
5+45	The Barre	Z689°		179.4	193			43.	1/5	DE		13	2.//	-	-3	-	[2]	JP)	Ko	17 12	ca
P	Mars.		8"	100.1	19-					-				1	(- /	,				
1 . "	"	1					1 .			1						-	·				

W.O. - WET DOISTY



APPENDIX G
PRECONSTRUCTION BLM TEST PIT LOGS



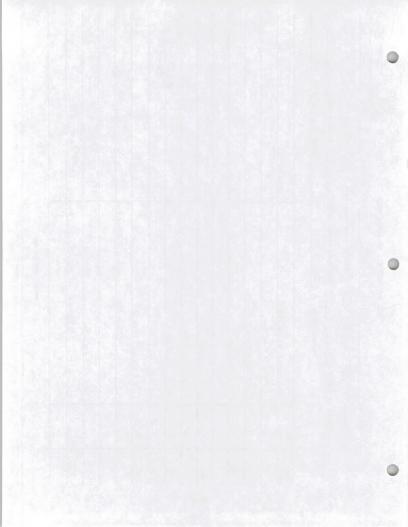
FEATURE

029	~	90-	3 -
LOG OF TEST PIL OR AUGER HO	LE		~ ~
PROJECT ANITA T	EST HOLE NO		
Ilway / Borrow Area Mate	rials /7	4h-++ 1 ++3	د

Foundation Spillway Depth of Shale _____ Depth to water table ____ Total Depth ________

Submitted by KK-LB Date 10-14

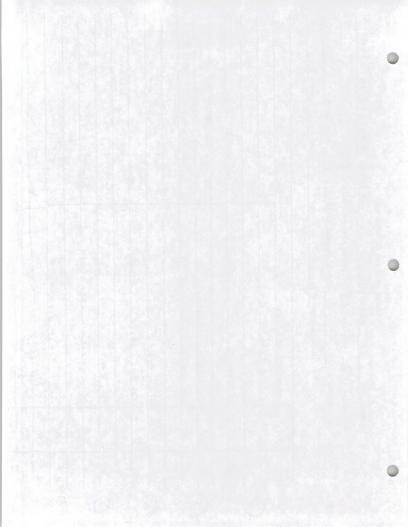
From: feet	To: Feet:	Description of Material	Remarks
0	/	Clay Loam	creek Bottom +- 4+25
1	4	Gravel daposit	
4	12	Heavy Clay	
0	18"	Silty Clay	5ta +- 3+00
18"	#	sand silt	/ /
4	4.5	sand Pea Grave	Deposition Area
4.5	6.5	sand s, It	Hrew
6.5	7.5	clayey Gravel	
7.5	10	Clayey shale Hard blocky	
0	12"	clay Loam	sta 1- 1+50
12"	8'	Clayey shale - Hard-blocky	Good STuff



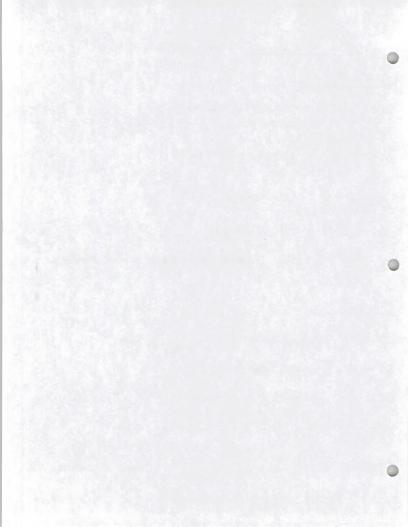
		acc of 1881 III ok ROOER	
	FEATUR	PROJECT Anta	TEST HOLE NO. See sketch sheet /
		ation Area M. Borrow Area M.	
		of Shale Depth to water to	
		Submitted by KK-LB	Date 10 -14-93
From:	To:		
feet	Feet:	Description of Material	Remarks
0	12"	silty Clay Loam	Stn +- 0+00 PPT()
12"	3'	clay	
_3	10'	clayer sit? sandy	Tack Sample #1
0	" عر	silty clay Luam	str +- 5+50
12"	8	clayer shale Hard Blacky	# Z same us hale #3
0	24 11	silty Clay Loom	
Z4"	9'	Clayey shale Blocky	sample #3
0	6"	Kay Loam	Borrow
6"	6.5	clay shale very hard - sn	nall blocky
O	8"	silty clay 20 um	Spepas, Tron
8 11	4	silty clay	1 > Dep
4	9	sondy silt	

	PEATUR	PROJECT Anto	TEST HOLE NO. See Sketch Sheet /
		ation D Spillway D Borrow Area Ma	
	Depth	of Shale Depth to water ta	ableTotal Depth
		Submitted by KK-LB	Date 10 -14-93
From:	To:		
feet	Feet:	Description of Material	Remarks Stn +- 0+00
0	12"	silty Clay Loan	Stn +- 0+00
12"	3'	clay	
3	10'	clayey silt? sandy	Taok Sample #1
0	ا" حار	silty clay Luam	stn +- 5+50
12"	8	clayey shale Hard Blacky	# Z Same as hole #3
0	2411	silty Clay 100 m	
Z4"	9'	Clayey shale Blocky	sample #3
0	٤"	Kay Loam	Borrow
6"	6.5	clay shale very hard - sn	rall blocky
o	8"	silty clay 20 um	Spepas, from
8 11	4	silty clay	1 > Der
4	9	sandy silt	

		LOG OF TEST FIT OR AUGER HO	
	PEATUR	RE PROJECT An, to	rest hole no. see sketch sheet
		ation D Spillway D Borrow Area Mate	
		of Shale Depth to water tabl	
		, <u>XX-28</u>	Date 10 -14-93
From: feet	To: Feet:	Parameter of Verendal	
0	12"	Sulty Clay Logn	Remarks
12"	3'	clay	
_3	10'	clayey silt? sandy	Took Sample #1
0	12"	silty Clay Luan	sta +- 5+50
12"	8	clayer shale Hord Blacky	# z same us hale #3)
0	24"	silty Clay Loom	
Z4"	9'	Clayey shale Blocky	sample #3
0	٤"	Clay Loam	Borrow
6"	6.5	clay shale very hard - sma	11 blocky
0	8"	Silty clay 20 um	Depas, Tion
8"	4	silty day	r > per
4	9	sondy solt	



14-14-77 ita - soils (see attached Map for Location goint A silty clay Loans Spadt open Sound Clayey shale silty clay Loans 8'=4' 4 = 10 10-11 (somple) Point B clay shale -very hard -small blocky 0'-8" E 11" Point C 5"-8" clay 200m > Top 6'15 Super 6'-8' silty day - pocice: Use d/s 8'-11 silty day - pocice: Toch of cobie



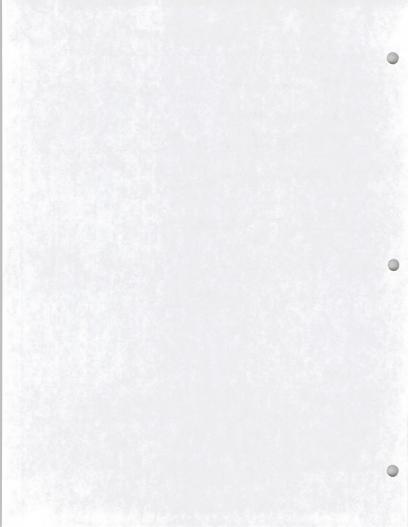
3ntD - Anita soils continued 8"- 6' clay shale 5 6- s' fine sond
6- s' silty clay, podcet use d/s
or mix
8'-11 Blocky Clay - Good stoff Point E - sample)

C-2 clay Loam

Z-10 fine Blocky clay

Strift

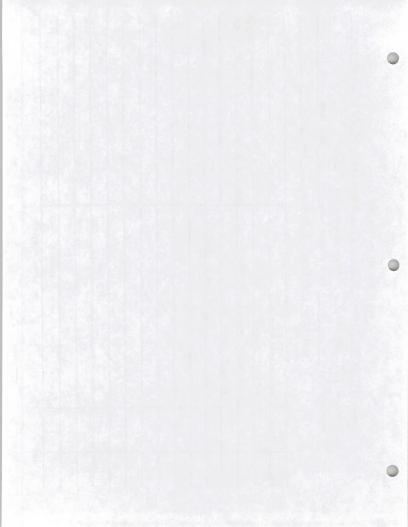
12-12-24



PEATURE 7557 HOUFS PROJECT PLANTH RES TEST HOLE NO. # 20 NEAR DT C Poundation Spillway Borrow Area Matarials Depth Depth of Shale Depth to water table Total Depth Submitted by LRB HAC LISANTE Date 6-21-95						
From:	To: Feet:	· · · · · · · · · · · · · · · · · · ·				
O		Description of Material	Remarks Component Turk 5			
/'	11.5'	CLAYEY LOAM - TOPSOIL FINE SILTY SAMD - POOR	2401 DD= 94 8 PUF 96 m= 94 95 TROXLET @ 4' - WD= 81.8 PV= M= 7.1 PCE			
		DO NOT USE!				
		poor THE LAY DUN!				
		SPECIFICATION STATES AND				
	1					

	FEATURE 7557 HMF5 PROJECT FAMILY RF5 TEST HOLE NO. # 20 APAN PT C Foundation Spillway Borrow Area Materials Depth of Shale Depth to water table Total Depth Submitted by LRB HAC LIBARY Date 6-21-95						
From: feet	To: Feet:	Description of Material	Remarks				
0	1	CLAYEY LOAM - 700501L					
1'	11.5'	FINE SILTY SAND - POOR	(7000 MOISTURE 2741 DD = 94 8 PF 96 m= 94 8 TROKEN P 4' - WD = 81.8 FF m= 7.1 FF				
		DO NOT USE!					
		poor ALL THE LAY DUN					

	FEATURE 7557 HMF5 PROJECT FAMILY RF5 TEST HOLE NO. # 20 APAN PT C Foundation Spillway Borrow Area Materials Depth of Shale Depth to water table Total Depth Submitted by LRB HAC LIBARY Date 6-21-95						
From: feet	To: Feet:	Description of Material	Remarks				
0	1	CLAYEY LOAM - 700501L					
1'	11.5'	FINE SILTY SAND - POOR	(7000 MOISTURE 2741 DD = 94 8 PF 96 m= 94 8 TROKEN P 4' - WD = 81.8 FF m= 7.1 FF				
		DO NOT USE!					
		poor ALL THE LAY DUN					



PEATURE BORROW	TH PROJECT ANITH TEST HO	DLE NO. # 2)
Foundation	Spillway Borrow Area Materials	\bowtie
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRB/HC/LR	Date 6-21-95

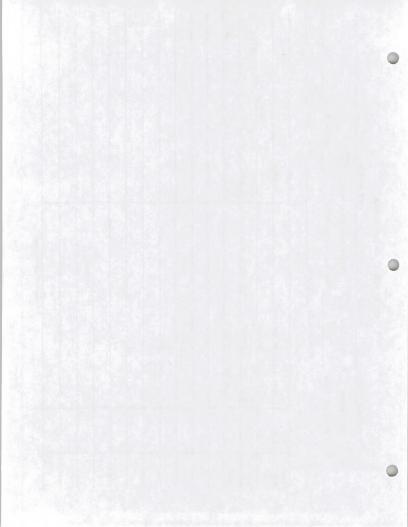
From: feet	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	- 8" Rending
1'	4.5'	SILTY CLAY-POSITIVY CORE MATERIAL	TROXER DO= 78.100 m 11.1 @ 3 MATE
4.5	4.0	CLAYEY LOAM SILTY CLAY-POSLINY COIL MATERIAL BLOCKEY CLAY-GOOD	7734 WD= 97.4 pcF, m= 17.6 pcF TROWER P4" DD= 79. 4 . 4/m = 22 % 6 DOTI
			A0213777 15 15 15 15 15 15 15 15 15 15 15 15 15

PEATURE BORROW	TH PROJECT ANITH TEST HO	DLE NO. # 2)
Foundation	Spillway Borrow Area Materials	\bowtie
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRB/HC/LR	Date 6-21-95

From: feet	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	- 8" Rending
1'	4.5'	SILTY CLAY-POSITIVY CORE MATERIAL	TROXER DO= 78.100 m 11.1 @ 3 MATE
4.5	4.0	CLAYEY LOAM SILTY CLAY-POSLINY COIL MATERIAL BLOCKEY CLAY-GOOD	7734 WD= 97.4 pcF, m= 17.6 pcF TROWER P4" DD= 79. 4 . 4/m = 22 % 6 DOTI
			A0213777 15 15 15 15 15 15 15 15 15 15 15 15 15

PEATURE BORRON	TH PROJECT ANITH TEST HOLE NO.	#21
Foundation	Spillway D Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRB/HC/LR Da	ite 6-21-95

From: feet	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	- 8" Rending
1'	4.5'	SILTY CLAY-POSITIVY CORE MATERIAL	TROXER DO= 78.100 m 11.1 @ 3 MATE
4.5	4.0	CLAYEY LOAM SILTY CLAY-POSLINY COIL MATERIAL BLOCKEY CLAY-GOOD	7734 WD= 97.4 pcF, m= 17.6 pcF TROWER P4" DD= 79. 4 . 4/m = 22 % 6 DOTI
			A0213777 15 15 15 15 15 15 15 15 15 15 15 15 15



PEATURE BORKOL	TH PROJECT ANITH PET TEST HO	LE NO. TH # 22
Foundation	Spillway Borrow Area Materials	Ser survey FOO location
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRR /HC	Date 6-21-95

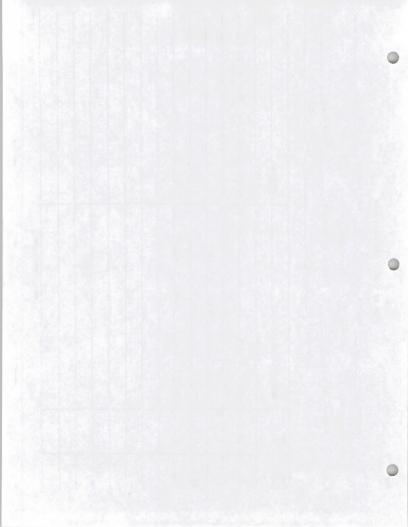
From: feet	To: Feet:	Description of Material	Remarks
0	6"	Clayey loan	Targoil
6"	3'.	BLOCKY CLAY STROKED & 6.5'-STILL BLOCKY COM	=2394 NO=104.7KF, M=15.0KE @31 TROUBE DO= 89.6KE 900 =14.8% @31
		STROKLER @ 6.5'-STILL BLOCKEY CHA	2629 WD= 99.6/FF, M= 16.4/AFE TIENER DD- 83.1/FF 9/M= 19,7%
3'	10.5'	BLOCKEY CLAY -GOOD STUFF	
10.5	11.51	SILTY SAND (FINE)	LENSE
11.5	13.5	BLOCKEY CLAY - GOOD STUFE	GOOD MOISTURE

PEATURE BORKOL	TH PROJECT ANITH PET TEST HO	LE NO. TH # 22
Foundation	Spillway Borrow Area Materials	Ser survey FOR location
Depth of Shale	Depth to water table	Total Depth
	Submitted by IRR/HC	Date 6-21-95

From: feet	To: Feet:	Description of Material	Remarks
0	6"	Clayey loom	Targoil
6"	3'.	BLOCKY CLAY 4" Reading ->	=2394 NO=104.7KF, M=13.0KE @31 TROUGH DO= 89.6KE 9/m=14.8% @31
		BLOCKY CLAY STROKED & 6.5'-STILL BLOCKY COM	2629 WD= 99.6/FF, M= 16.4/AFE TIENER DD- 83.1/FF 9/M= 19,7%
3'	10.5'	BLOCKEY CLAY -GOOD STUFE	
10.5	11.5'	SILTY SAND (FINE)	LENSE
11.5	13.5	BLOCKEY CLAY - GOOD STUFE	GOOD MOISTURE

PEATURE BORKOL	TH PROJECT ANITH PET TEST HO	LE NO. TH # 22
Foundation	Spillway Borrow Area Materials	Ser survey FOR location
Depth of Shale	Depth to water table	Total Depth
	Submitted by IRR/HC	Date 6-21-95

From: feet	To: Feet:	Description of Material	Remarks
0	6"	Clayey loom	Targoil
6"	3'.	BLOCKY CLAY 4" Reading ->	=2394 NO=104.7KF, M=13.0KE @31 TROUGH DO= 89.6KE 9/m=14.8% @31
		BLOCKY CLAY STROKED & 6.5'-STILL BLOCKY COM	2629 WD= 99.6/FF, M= 16.4/AFE TIENER DD- 83.1/FF 9/M= 19,7%
3'	10.5'	BLOCKEY CLAY -GOOD STUFE	
10.5	11.5'	SILTY SAND (FINE)	LENSE
11.5	13.5	BLOCKEY CLAY - GOOD STUFE	GOOD MOISTURE



JUST DEED TREE

Foundation / Spi	llway Borrow Area Materials		
Depth of Shale	Depth to water table	Total Depth	

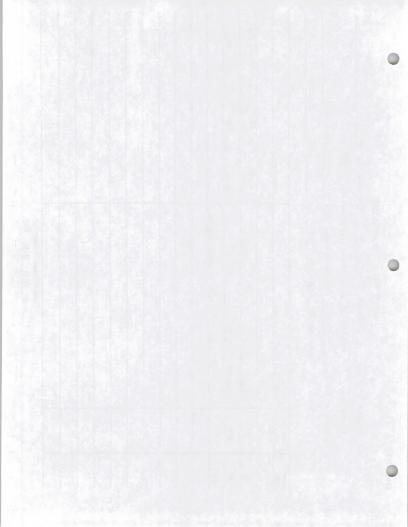
from:	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	po of arading
1	4'	BLOCKEY CLAY -GOOD STUFF	12708 го= 980, га, т= 16.6 рсЕ 71041511 00= 81.3 р = 12 - 20.5 6
4'	10.5'	Blacke 4 CLMY - "	SAMUE @ 9' FOR PROCTOR
10.5	./3'	SILTY SAND - COULDN'T GO DESPITE	

EATURE BOTHOW	PROJECT ANITH RES TEST HOI	LE NO. 423
oundation	Spillway Borrow Area Haterials	
Depth of Shale	Depth to water table	Total Depth
e,	buitted by 188/HC 144 168	Date /-21-95

rom: feet	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	po of acading
1	4'	BLOCKEY CLAY -GOOD STUFF	p 4 1 media 22708 NO=980, M = 16.6 PEE TROMER DO=81.3 N = 2 -20.5 &
4'	10.5'	Blacke 4 Ciny - ""	SAMUE @ 9' FOR PROCTOR
10.5	./3'	SILTY SAND - COULDN'T GO DEEDER	

EATURE BOTHOW	PROJECT ANITH DES TEST HOI	LE NO. 423
oundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth
	Submitted by 178/HC 146 168	Date 6-21-95

rom: feet	To: Feet:	Description of Material	Remarks
0	1	CLAYEY LOAM	po of acading
1	4'	BLOCKEY CLAY -GOOD STUFF	p 4 1 media 22708 NO=980, M = 16.6 PEE TROMER DO=81.3 N = 2 -20.5 &
4'	10.5'	Blacke 4 Ciny - ""	SAMUE @ 9' FOR PROCTOR
10.5	./3'	SILTY SAND - COULDN'T GO DEEDER	



PEATURE BORROW	PROJECT ANITA TEST HOLE NO. #24	
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table Total Depth	
	Submitted by LRR/HC/KK- Date 6-21-95	

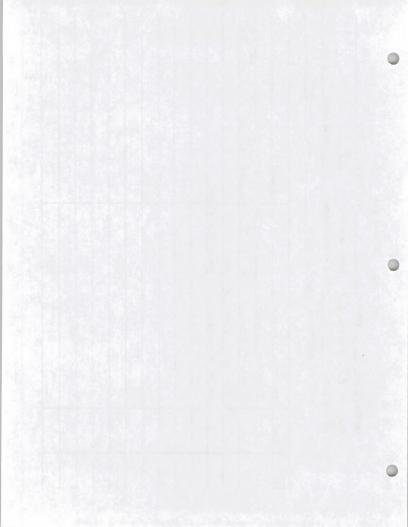
From: feet	To: Feet:	Description of Material	Remarks
0'	1	CLAYEY LOAM	TO1401L
1'	13'	BLOCKEY CLAY - 1200 STUFF	TONGOIL @ 3.5 1 = 2620 40 = 95.7 1: M-17.7 TRONFR @ 4" M= 82.0 1 11.6%
		ALL THE LAY POUND	
		- MOST PRORAGIE FOR RODRAN IN CO	WE.
	12.5		

PEATURE BORROW	PROJECT ANITA TEST HOLE NO. #24	
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table Total Depth	
	Submitted by LRR/HC/KK- Date 6-21-95	

From: feet	To: Feet:	Description of Material	Remarks
0'	1	CLAYEY LOAM	TO1401L
1'	13'	BLOCKEY CLAY - 1200 STUFF	TONGOIL @ 3.5 1 = 2620 40 = 95.7 1: M-17.7 TRONFR @ 4" M= 82.0 1 11.6%
		ALL THE LAY POUND	
		- MOST PRORAGIE FOR RODRAN IN CO	WE.
	12.5		

PEATURE BORROW	PROJECT ANITA TEST HOL	E NO. #24
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRR/HC/KK	Date 6-21-95

rom:	To: Feet:	Description of Material	Remarks
> '	1'	CLAYEY LOAM	7014014
1'	13'	BLOCKEY CLAY - GOOD STUFF	TO1401L @351 = 2670 40= 95.71: M-17.7 TRONFA @4" D= 82.0 13: 11.6%
		BLOCKEY CLAY - GOOD STURE	
		- MOST DRORAGIE FOIL ROPROW INC	URE,



PEATURE BORROW	PROJECT ANITH TEST HOL	E NO. #25	
Foundation	Spillway Borrow Area Materiala	\square	
Depth of Shale	Depth to water table	Total Depth	
	Submitted by LRB/HC /LBANTE	Date 6-21-95	

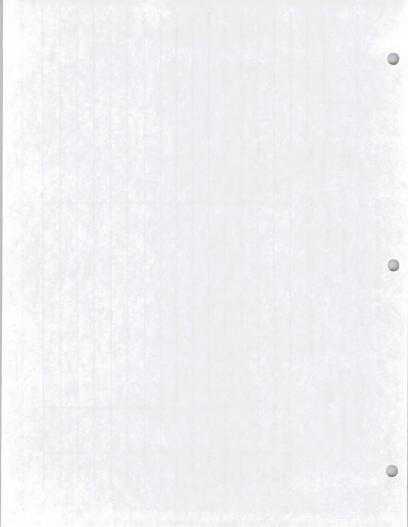
From: feet	To: Feet:	Description of Material	Remarks
0	6"	CLAYEY LOAM	TOPROIL
6"	10'	BLOCKEY CLAY - GOOD	TOPGOIL 76.7, 84" WO = 98.4, M = 15.2 TROWER & 4' DD = 33.4 % = 18.3 NOTHING TO WARD Y AROUT
10'	10.5	BLOCKY CLAY - GOOD SILTY SAND - LEASE JULIET BLOCKY CLAY - REAL GOOD	Nothing to work & ABOUT
10.5	12'	BLOCKY CLAY- REAL GOOD	

PEATURE BORROW	PROJECT ANITH TEST HOL	E NO. #25	
Foundation	Spillway Borrow Area Materiala	\square	
Depth of Shale	Depth to water table	Total Depth	
	Submitted by LRB/HC /LBANTE	Date 6-21-95	

From: feet	To: Feet:	Description of Material	Remarks
0	6"	CLAYEY LOAM	TOPROIL
6"	10'	BLOCKEY CLAY - GOOD	TOPGOIL 76.7, 84" WO = 98.4, M = 15.2 TROWER & 4' DD = 33.4 % = 18.3 NOTHING TO WARD Y AROUT
10'	10.5	BLOCKY CLAY - GOOD SILTY SAND - LEASE JULIET BLOCKY CLAY - REAL GOOD	Nothing to work & ABOUT
10.5	12'	BLOCKY CLAY- REAL GOOD	

PEATURE BORROW	PROJECT ANITH TEST HOL	E NO. #25	
Foundation	Spillway Borrow Area Materiala	\square	
Depth of Shale	Depth to water table	Total Depth	
	Submitted by LRB/HC /LBANTE	Date 6-21-95	

From: feet	To: Feet:	Description of Material	Remarks
0	6"	CLAYEY LOAM	TOPROIL
6"	10'	BLOCKEY CLAY - GOOD	TOPGOIL 76.7, 84" WO = 98.4, M = 15.2 TROWER & 4' DD = 33.4 % = 18.3 NOTHING TO WARD Y AROUT
10'	10.5	BLOCKY CLAY - GOOD SILTY SAND - LEASE JULIET BLOCKY CLAY - REAL GOOD	Nothing to work & ABOUT
10.5	12'	BLOCKY CLAY- REAL GOOD	



From:

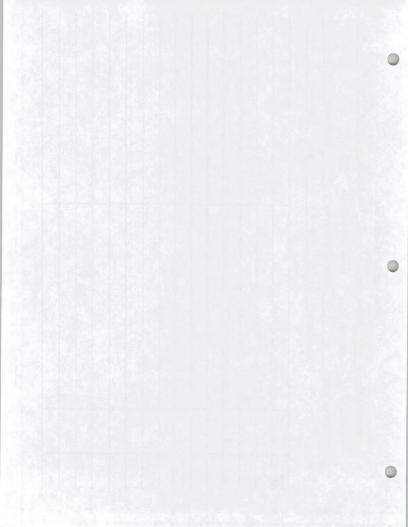
43/ 41/				
PRATURE BORROW-PRIMET PROJECT ARILA ROS TEST HOLE NO. #26- Mossit do W/4				
	Foundation Spillway Borrow Area Materials			
Depth	of Shale Depth to water table	Total Depth		
	Submitted by LRR/HC/LR	Date 6-77-95		
To:				
Feet:	Description of Material	Remarks		
1'	CLAYEY LOAM	TOROLL		
6'	CLAYEY LOAM Blockey Clay -GOOD SHITE GAND TREACHER ALAT-MIT & GOOD	- 3:11 e4" LU= 983 , m= 10.0 TRONER @ 3.5' DO= 88.8 9m = 11.3		
13'	SILTY SAND IRLOCKET CLAY-NOT & GOOD	Canple teken From 10'		
-35 8500-3				
	4			

From:

43/ 41/				
PRATURE BORROW-PRIMET PROJECT ARILA ROS TEST HOLE NO. #26- Mossit do W/4				
	Foundation Spillway Borrow Area Materials			
Depth	of Shale Depth to water table	Total Depth		
	Submitted by LRR/HC/LR	Date 6-77-95		
To:				
Feet:	Description of Material	Remarks		
1'	CLAYEY LOAM	TOROLL		
6'	CLAYEY LOAM Blockey Clay -GOOD SHITE GAND TREACHER ALAT-MIT & GOOD	- 3:11 e4" LU= 983 , m= 10.0 TRONER @ 3.5' DO= 88.8 9m = 11.3		
13'	SILTY SAND IRLOCKET CLAY-NOT & GOOD	Canple teken From 10'		
-35 8500-3				
	4			

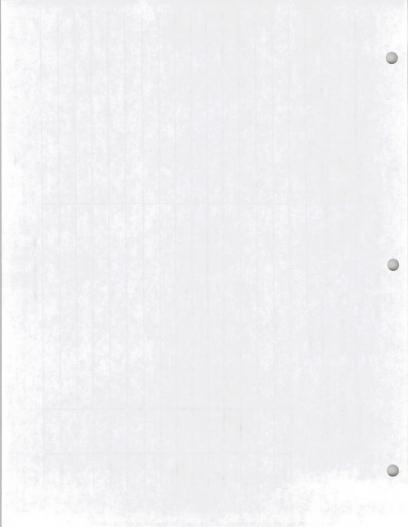
From:

43/ 41/				
PRATURE BORROW-PRIMET PROJECT ARILA ROS TEST HOLE NO. #26- Mossit do W/4				
	Foundation Spillway Borrow Area Materials			
Depth	of Shale Depth to water table	Total Depth		
	Submitted by LRR/HC/LR	Date 6-77-95		
To:				
Feet:	Description of Material	Remarks		
1'	CLAYEY LOAM	TOROLL		
6'	CLAYEY LOAM Blockey Clay -GOOD SHITE GAND TREACHER ALAT-MIT & GOOD	- 3:11 e4" LU= 983 , m= 10.0 TRONER @ 3.5' DO= 88.8 9m = 11.3		
13'	SILTY SAND IRLOCKET CLAY-NOT & GOOD	Canple teken From 10'		
-35 8500-3				
	4			



	LOG OF TEST . OR AUGER HOLE	
PEATURE BORROW	LOG OF TEST . OR AUGER HOLE PROJECT ANTA FEE TEST HOLE	LE NO. <u>477</u>
Foundation	Spillway Borrow Area Materials	\bowtie
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRD /HC // K	Date 6-77.75

rom: feet	To: Feet:	Description of Material	Remarks
0	6"	CLAYEY LOAM	TOPSON
6"	11'	BLOCKEY CLAY-GOOD	= 1846 27 , N = 1/1, 2 M = 15.7 TICKEN 70=95.7 9M= 15.9
		TOOGH TO DIS	



PEATURE BORROW	PROJECT ANITH RES TEST HOL	E NO. #78
Foundation	Spillway Borrow Area Materials	an pent sours t
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRR /HC /LR /EBRADA	EY Date 6-27-75 /7-5-95

From: feet	To: Feet:	Description of Material	Remarks
6	6"	CLAYEY LOAM	70/401L 2566 40=116.7 11=15.77
6' 6' 5' 5.5	5'	NOCKEY CLAY -GOOD	Trocker @ 35 10- 100 Que 15.5
5	5.5	SCATTERED SILTY SAND POLCETS	IN RETWEEN CLAY - O.K. WORLY
5.5	12'	Blockey clay - Good	780 x 1885 WD=120.6 M= 14.0 KT
17'	13'	SLOCKEY Clay - Good BLOCKEY Clay - Good BLOCKEY Clay - Mined who to it.	e4" opth 2389, mc=199 wp=120.5 m= 20.3 p.f.
		Got relyer as an un + Dour	
1			

PEATURE BORROW	PROJECT ANITH RES TEST HOL	E NO. #78
Foundation	Spillway Borrow Area Materials	an pent sours t
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRR /HC /LR /EBRADA	EY Date 6-27-75 /7-5-95

From: feet	To: Feet:	Description of Material	Remarks
6	6"	CLAYEY LOAM	70/401L 2566 40=116.7 11=15.77
6' 6' 5' 5.5	5'	NOCKEY CLAY -GOOD	Trocker @ 35 10- 100 Que 15.5
5	5.5	SCATTERED SILTY SAND POLCETS	IN RETWEEN CLAY - O.K. WORLY
5.5	12'	Blockey clay - Good	780 x 1885 WD=120.6 M= 14.0 KT
17'	13'	SLOCKEY Clay - Good BLOCKEY Clay - Good BLOCKEY Clay - Mined who to it.	e4" opth 2389, mc=199 wp=120.5 m= 20.3 p.f.
		Got relyer as an un + Dour	
1			

PEATURE BORROW	PROJECT ANITH RES TEST HOL	E NO. #78
Foundation	Spillway Borrow Area Materials	an pent sours t
Depth of Shale	Depth to water table	Total Depth
	Submitted by LRR /HC /LR /EBRADA	EY Date 6-27-75 /7-5-95

From: feet	To: Feet:	Description of Material	Remarks
6	6"	CLAYEY LOAM	70/401L 2566 40=116.7 11=15.77
6' 6' 5' 5.5	5'	DUCKEY CLAY -GOOD	Trocker @ 35 10- 100 Que 15.5
5	5.5	SCATTERED SILTY SAND POLCETS	IN RETWEEN CLAY - O.K. WORLY
5.5	12'	Blockey clay - Good	780 x 1885 WD=120.6 M= 14.0 KT
17'	13'	SLOCKEY Clay - Good BLOCKEY Clay - Good BLOCKEY Clay - Mined who to it.	e4" opth 2389, mc=199 wp=120.5 m= 20.3 p.f.
		Got relyer as an un + Dour	
1			



0 9	0	4	PIPE SIM		5755
			LOG OF TEST .	OR	AUGER HOLE

PEATURE CL T	# PROJECT ANITH RES TEST HOL	E NO. TH # 29
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth 13,5
	Submitted by HAC /TS / LR /ER	Date

	Description of Material	Remarks
6"	20AM	TOPKOIL
40	SILTY SAND - POOR	poor
7'	SANDY GRAVEL- POOR	ROOR
13.5	BLUGGH HEAVY CLAY - GOOD	FAT CLAY - EXCELLENT
		PROCTOR SAMPLE @ 13'
	NO TROXIER DELKITIES TOO	
The second		
	7'	4' SILTY SAND POOR 7' SANNY GRAVEL- POOR

0 9	0	4	PIPE SIM		5755
			LOG OF TEST .	OR	AUGER HOLE

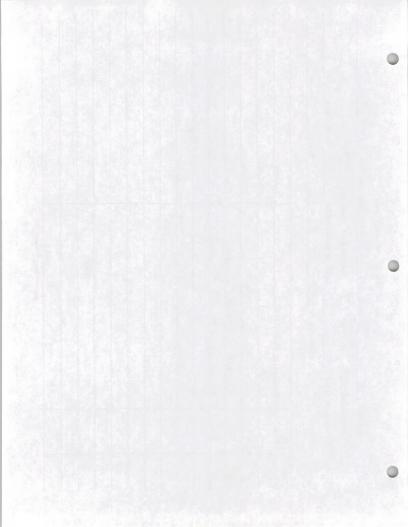
PEATURE CL T	# PROJECT ANITH RES TEST HOL	E NO. TH # 29
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth 13,5
	Submitted by HAC /TS / LR /ER	Date

	Description of Material	Remarks
6"	20AM	TOPKOIL
40	SILTY SAND - POOR	poor
7'	SANDY GRAVEL- POOR	ROOR
13.5	BLUGGH HEAVY CLAY - GOOD	FAT CLAY - EXCELLENT
		PROCTOR SAMPLE @ 13'
	NO TROXIER DELKITIES TOO	
The second		
	7'	4' SILTY SAND POOR 7' SANNY GRAVEL- POOR

0 9	0	4	PIPE SIM		5755
			LOG OF TEST .	OR	AUGER HOLE

PEATURE CL T	# PROJECT ANITH RES TEST HOL	E NO. TH # 29
Foundation	Spillway Borrow Area Materials	
Depth of Shale	Depth to water table	Total Depth 13,5
	Submitted by HAC /TS / LR /ER	Date

	Description of Material	Remarks
6"	20AM	TOPKOIL
40	SILTY SAND - POOR	poor
7'	SANDY GRAVEL- POOR	ROOR
13.5	BLUGGH HEAVY CLAY - GOOD	FAT CLAY - EXCELLENT
		PROCTOR SAMPLE @ 13'
	NO TROXIER DELKITIES TOO	
The second		
	7'	4' SILTY SAND POOR 7' SANNY GRAVEL- POOR



PEATURE TEST	THING PROJECT ANITA RES TEST HOL	E NO. #30 DS	£ STA. 6+65
Foundation A	Spillway Borrow Area Materials		
Depth of Shale	Depth to water table	Total Depth	
	Submitted by HAC ITS 112 1=2	Date 7-6-95	

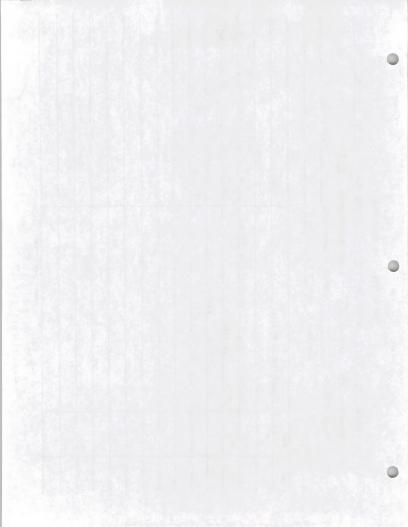
From: feet	To: Feet:	Description of Material	Remarks
0"	6"	LOAM SANDY	7075011
6" 4.5	4.5	CLAYEY SILT - Held to Dig though	E HILDORIL DG= 2053, MG= 489, AD= 1113
	5.5	Giard - DOOR	780XER @ 95 DD= 109 m= 223 2 204
5.5	8.5	SAND /SILT - POOR	TRONGER @ 95 DD = 104, 1 m = 72, 3 & 204 DC = 841, nc=268, aD = 112 7 Book souther @ 95 DD = 89.3 m= 25.3 &=26.1
8.5'	13.0	Heavy Blocker Clay	6000 STUFF / EXPLIENT
		The state of the s	

PEATURE TEST	THING PROJECT ANITA RES TEST HOL	E NO. #30 DS	£ STA. 6+65
Foundation A	Spillway Borrow Area Materials		
Depth of Shale	Depth to water table	Total Depth	
	Submitted by HAC ITS 112 1=2	Date 7-6-95	

From: feet	To: Feet:	Description of Material	Remarks
0"	6"	LOAM SANDY	7075011
6" 4.5	4.5	CLAYEY SILT - Held to Dig though	E HILDORIL DG= 2053, MG= 489, AD= 1113
	5.5	Giard - DOOR	780XER @ 95 DD= 109 m= 223 2 204
5.5	8.5	SAND /SILT - POOR	TRONGER @ 95 DD = 104, 1 m = 72, 3 & 204 DC = 841, nc=268, aD = 112 7 Book souther @ 95 DD = 89.3 m= 25.3 &=26.1
8.5'	13.0	Heavy Blocker Clay	6000 STUFF / EXPLIENT
		The state of the s	

PEATURE TEST	THING PROJECT ANITA RES TEST HOL	E NO. #30 DS	£ STA. 6+65
Foundation A	Spillway Borrow Area Materials		
Depth of Shale	Depth to water table	Total Depth	
	Submitted by HAC ITS 112 1=2	Date 7-6-95	

From: feet	To: Feet:	Description of Material	Remarks
0"	6"	LOAM SANDY	7075011
6" 4.5	4.5	CLAYEY SILT - Held to Dig though	E HILDORIL DG= 2053, MG= 489, AD= 1113
	5.5	Giard - DOOR	780XER @ 95 DD= 109 m= 223 2 204
5.5	8.5	SAND /SILT - POOR	TRONGER @ 95 DD = 104, 1 m = 72, 3 & 204 DC = 841, nc=268, aD = 112 7 Book souther @ 95 DD = 89.3 m= 25.3 &=26.1
8.5'	13.0	Heavy Blocker Clay	6000 STUFF / EXPLIENT
		The state of the s	



PEATURE TELT +	PROJECT_	ANITH RES TEST HO	DLE NO. #71 103	DS 51A, 6+10
Foundation	Spillway	Borrow Area Materials		
Depth of Shale		Depth to water table	Total Depth	
	Submitted by		Date	

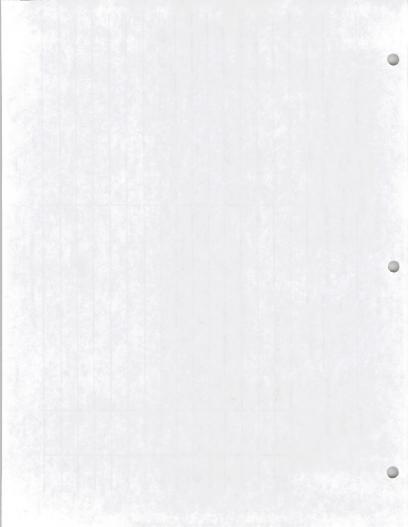
From: feet	To: Feet:	Description of Material	Remarks
0"	z'	SANDY JOAM	70P501L
z'	6	SAND / GRAVEL	70PSO/L @8"mpth 0c=1072, mc=234, ND=126.0 TROXLER @ 5.5', NO=107.0 m=24.0 1/m-23.5
z'	10.5		Good Hany Clay
7.057	≈ 3.5'	To check density on said/as	not to take sample
		11' 70 1 50011 1431	
		INSITU TROXUER TEST @ 3.5'8"M	DC=1788 mc=1/3, NO=106.2 10 D= 95.4 m=10.8 %m=11.3
-1			

PEATURE TELT +	PROJECT_	ANITH RES TEST HO	DLE NO. # 71 103	DS 51A, 6+10
Foundation	Spillway	Borrow Area Materials		
Depth of Shale		Depth to water table	Total Depth	
	Submitted by		Date	

From: feet	To: Feet:	Description of Material	Remarks
0"	z'	SANDY JOAM	70P501L
z'	6	SAND / GRAVEL	70PSO/L @8"mpth 0c=1072, mc=234, ND=126.0 TROXLER @ 5.5', NO=107.0 m=24.0 1/m-23.5
6	10.5'		Good Hany Clay
7057	≈ 3.5'	To chart density on said/as	not to take sample
		11 70 1 50011 1421	
		INSITU TROXLER TEST @ 3.5'8"	DC=1788 mc=113, NO=106.2 th DD=95.4 m=10.8 %m=11.3
	3/2		

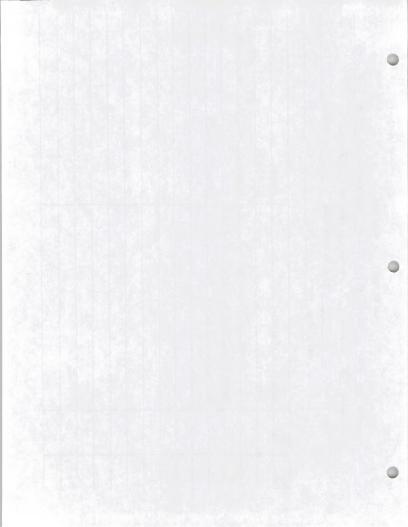
PEATURE TELT +	PROJECT_	ANITH RES TEST HO	LE NO. # 71 103	DS 51A, 6+10
Foundation	Spillway	Borrow Area Materials		
Depth of Shale		Depth to water table	Total Depth	
	Submitted by		Date	

rom: feet	To: Feet:	Description of Material	Remarks
0"	z'	SANDY JOAM	70P501L
z'	6	SAND / GRAVEL	TOP SO IC @ 8" Apth OC= 1072, MC= 234, ND= 126.0 TROXLER @ 5.5', NO= 102.0 M= 24.0 4M=238
z'	10.5'		Good Havy Clay
7.057	€ 3.5'	To chart density on said/as	nel to take sample
		11' 70 1 50011 .421	the second secon
		INSITU TROXLER TEST @ 3.5'8"	DC=1788 mc=1/3, NO=106.2 16 DD=95.4 m=10.8 %m=11.3
	1000		



PEATURE TEST +	PROJECT ANTH PRES TEST HO	LE NO# 3Z @ 57A. 5409
Foundation 💹	Spillway Borrow Area Materials	an Bench
Depth of Shale	Depth to water table	Total Depth
	Submitted by HAC/TS/LB/EB	Date 17-6-95

m:	To: Feet:	Description of Material	Remarks
μ	1'	LOAM	708 5011
	4'	SILTY SAND - POOR Test for inquiring SAND/ Grand longer . POOR + take out Heavy Clay - Good cose	TOP SOIL 88" DC = 1452 mc = 0069 LD = 114,8 TRONGO B5' PD = 109,8 M = 6.0 2m = 4
,	9.5'	SANDI Gravel longer . DOOR - take out	
5'	11.5'	Heavy Clay - Good cose	Good stuff
	7.0		
		A DOMESTIC AND A SECOND OF THE SECOND ASSESSMENT	



APPENDIX H

PRECONSTRUCTION LABORATORY TEST DATA



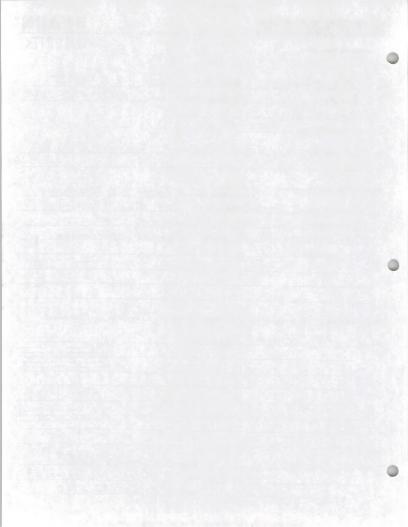
Letter of Transmittal

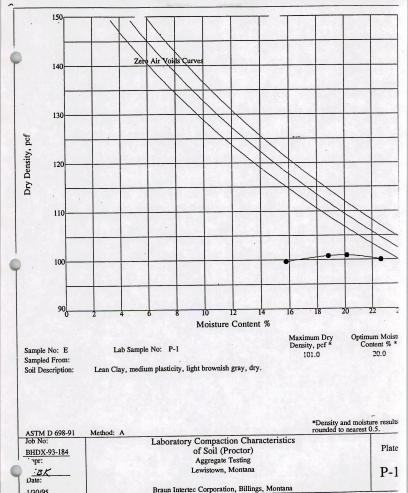
BRAUN*
INTERTEC

un Intertec Corporation

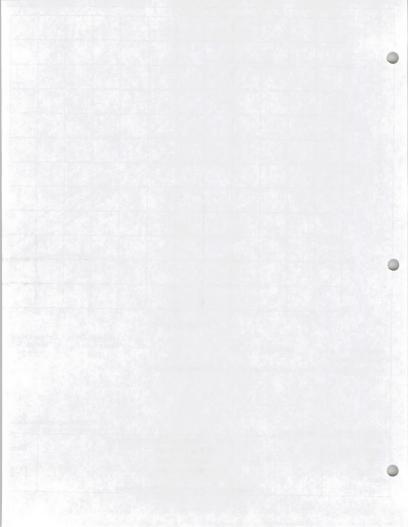
NEW

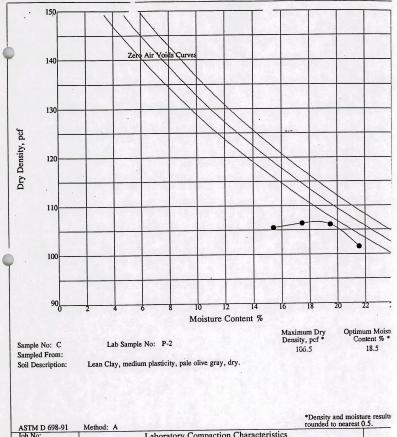
							,
. M.	s. MAI	RGRET L	. WESTHO	FF	Date: _	1/	31/95
Bus	EAU	F LAND	MANAGEN	AFAT	Job No: _	BHD	x -93-184
	PORT		AT BOOK				
LE	WISTOW	, MT	5945	7			
			- 0		_		
Re:	ABORA	TORY T.	EST KE	SULTS	: 5,	AMPLES	E,<, B.
We are sending	vou the follow	ring items:	attached			(>)	1 480015000
			under separate a	over via	HREE	(3)	LABORATORY
_6	MPACTION	CHAR	CTERISTI	45	5 S	014	PROCTOR)
PER	FORMED	ON	SAMPLES	SURA	MITTED	: E	, < , B.
ONE	ATT	FRBERG	LIMIT-	s Re	SULTS	PER	FORMAD
		LE B.					
- CN	SAMP	<u> </u>	ANT TO THE				
							.,
These are being	g sent:	for approval	for review of	nd comment	☐ fe	or your use	as requested
Remarks:	Br	LARRY	BIRDU	FLL		Did.	ASSCO DM.
+ 12						OPS ADM (& B)	
						MIN	OTHER TOWN DISTRIC
T							90
			44.4				FEB 0 1 1995
5							COORD RESP
-						COPI	ES FUR
-							
					Sto	~ B	Klotz
py to:					Min	C 45	FUGUNESS
_				Title: _	10141	1 LE	2-3930
				Phone: _	(408	, 63.	2-2/30



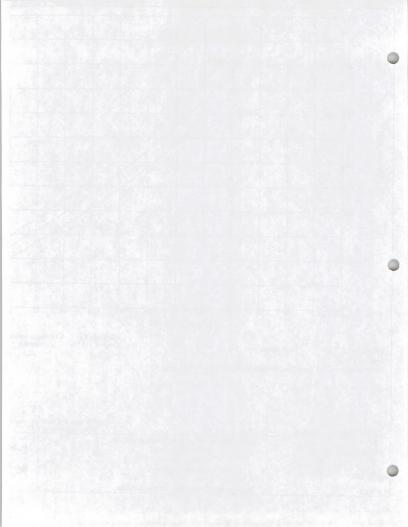


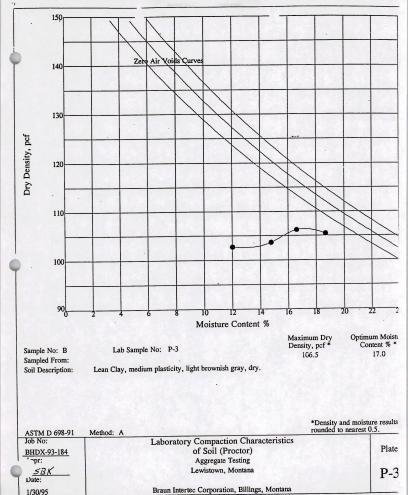
1/30/95

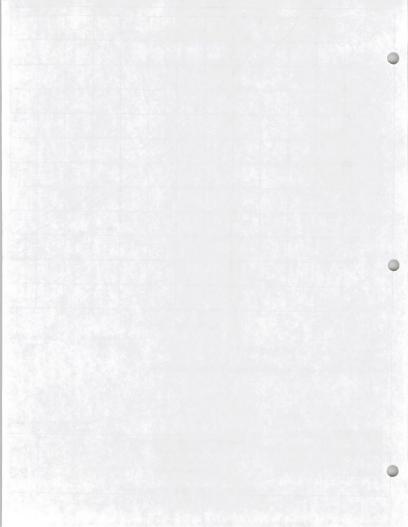


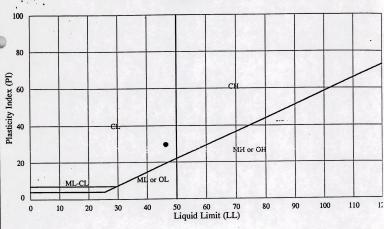


ASTM D 698-91	Method: A		*Density and moisture r rounded to nearest 0.5.	esults
Job No: BHDX-93-184		Laboratory Compaction Characteristics of Soil (Proctor)		Plate
pr:		Aggregate Testing		
Date:		Lewistown, Montana		P-2
1/30/95		Braun Intertec Corporation, Billings, Montana		







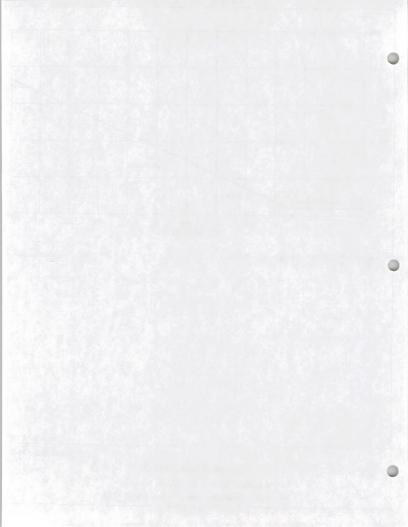


January 31, 199

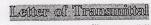
Project BHDX-93-18

Atterberg Limits' Results

Aggregate Testing, Lewistown, Montana Braun Intertec Corporation, Billings, Montana (406) 652-3930

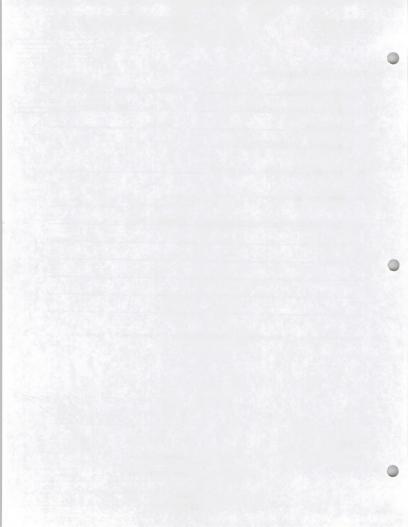


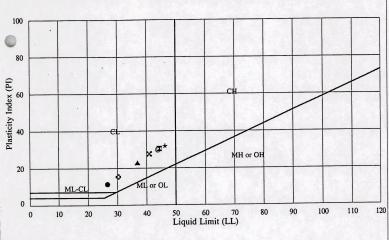
BRAUN"





		AUG 1 1 1995
To: Attn: Herb Chavez		Date: August 10, 1995
Bureau of Land Management		Job No: BHDX-951137
Airport Road		Fax No.:
Lewistown , Montana 59457		
Re: Laboratory Test Results: Anita	Resivoir	
We are sending you the following items:	8	Attached Under separate cover via
11 Proctors, 7 Atterberg Limits, Or	der Numb	er 1422E060P50100
		D for your use. D as requested
Priest are being sens	for review as	id comment □ for your use □ as requested
These are being sent: for approval Remarks:	for review as	nd comment
Priest are being sens	for review as	nd comment for your use
Priest are being sens	for review at	ad comment for your use as requested
Priest are being sens	for review as	Steve B Klotz
Remarks:		Star B X logs





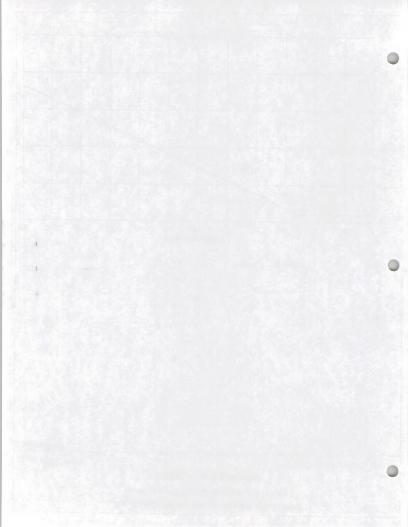
Sample No.	Depth 3'	LL 27	PL 15	PI 11	
	3'	44	14	31	
	9'	37	14	23	
	6'	46	14	32	
	12'	41	13	28	
		30	15	15	
28	9'	44	14	30	
	21 22 23 24 25 26	21 3' 22 3' 23 9' 24 6' 25 12'	21 3' 27 22 3' 44 23 9' 37 24 6' 46 25 12' 41 26 30	21 3° 27 15 22 3° 44 14 23 9° 37 14 24 6° 46 14 25 12' 41 13 26 30 15	21 27 15 11 22 3' 44 14 31 23 9' 37 14 23 24 6' 46 14 32 25 12' 41 13 28 26 30 15 15

August 10, 1995

Project BHDX-95-137

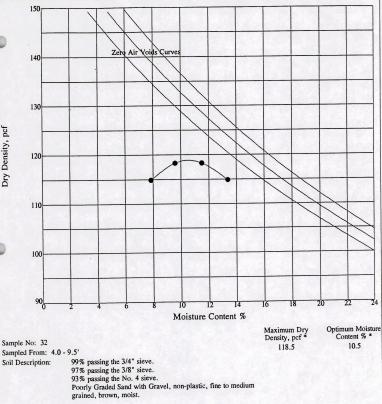
Atterberg Limits' Results

Bureau of Land Management, Anita Resevior Braun Intertec Corporation, Billings, Montana (406) 652-3930

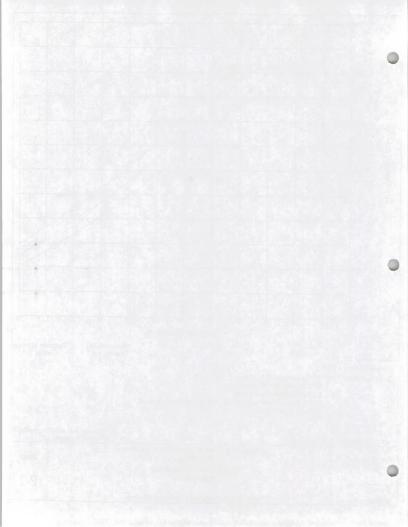


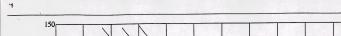
Dry Density, pcf

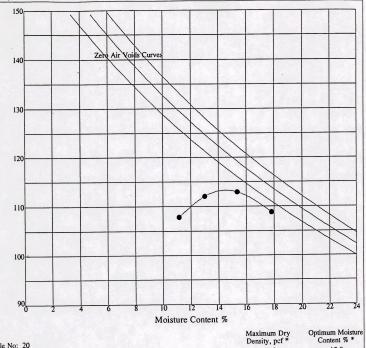
8/10/95



*Density and moisture results rounded to nearest 0.5. Method: B ASTM D 698-91 Laboratory Compaction Characteristics Job No: Plate of Soil (Proctor) 'DX-95-137 Bureau of Land Management P-1 Anita Resevior Date: Braun Intertec Corporation, Billings, Montana







Sample No: 20 Sampled From: 4 Soil Description:

Dry Density, pcf

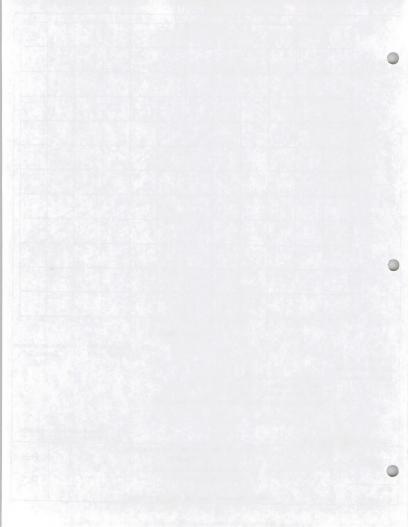
100% passing the 3/4" sieve. 100% passing the 3/8" sieve. 99% passing the No. 4 sieve.

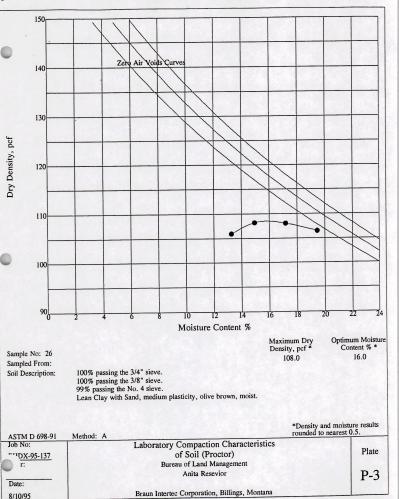
Sandy Lean Clay, medium plasticity, brown, moist.

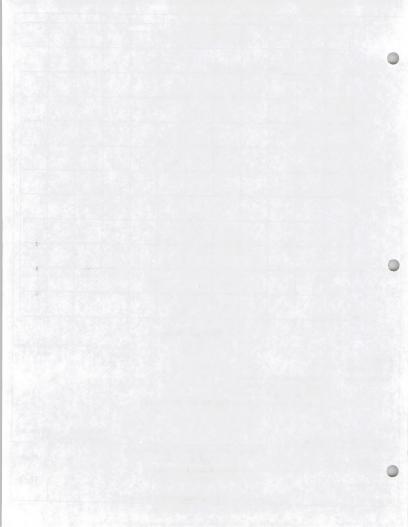
113.0 15.0

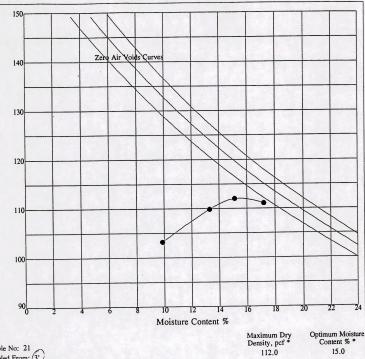
ASTM D 698-91	Method: A		*Density and moisture results rounded to nearest 0.5.	;
Job No:	Incured: 11	Laboratory Compaction Characteristics		
PUDX-95-137		of Soil (Proctor)	Plate	;
r:		Bureau of Land Management		
		Anita Resevior	P-2	2

Date: Braun Intertec Corporation, Billings, Montana 8/10/95









Sample No: 21 Sampled From: 3' Soil Description

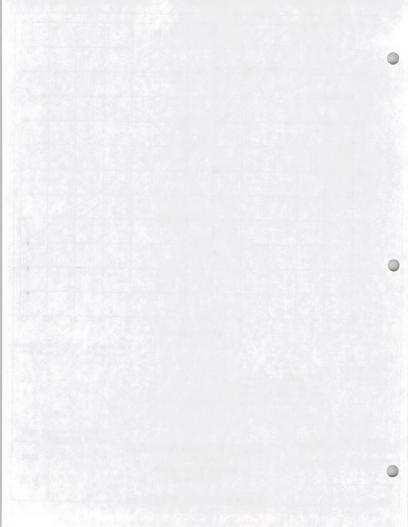
Dry Density, pcf

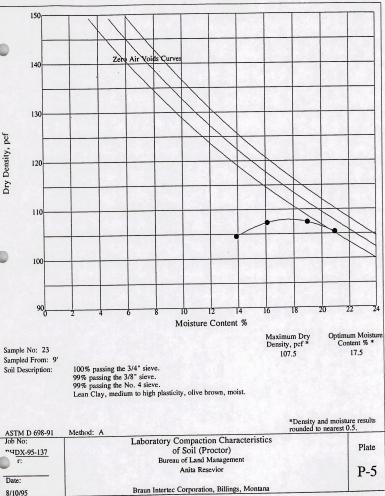
100% passing the 3/4" sieve. 99% passing the 3/8" sieve. 99% passing the No. 4 sieve.

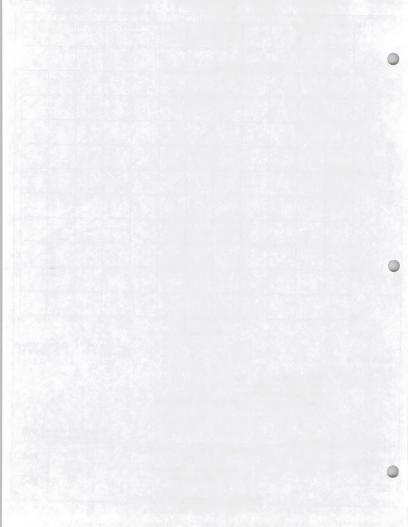
Sandy Lean Clay, low to medium plasticity, olive brown, moist.

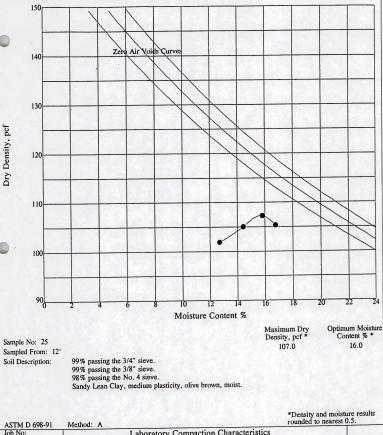
*Density and moisture results rounded to nearest 0.5. ASTM D 698-91 Method: A Laboratory Compaction Characteristics Job No: Plate of Soil (Proctor) РЧDX-95-137 Bureau of Land Management Anita Resevior P-4 Date:

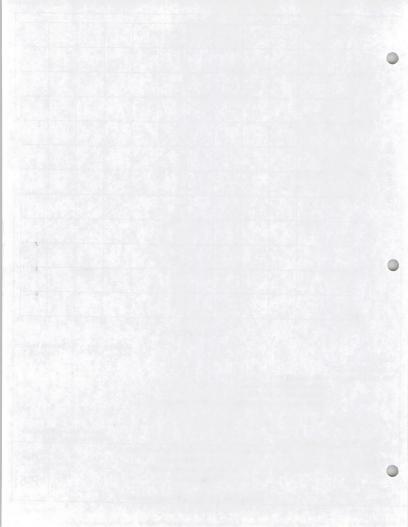
Braun Intertec Corporation, Billings, Montana 8/10/95



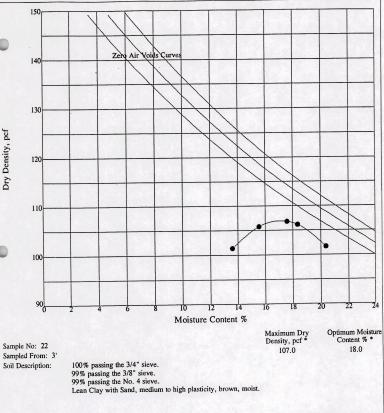




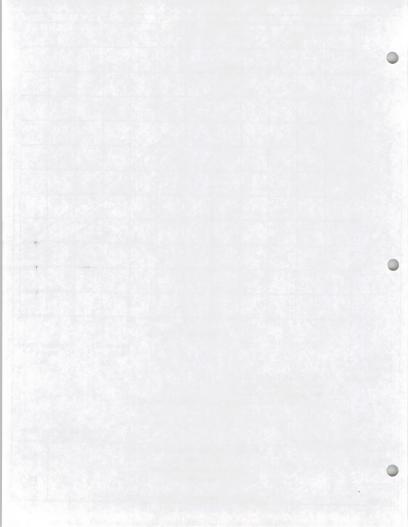




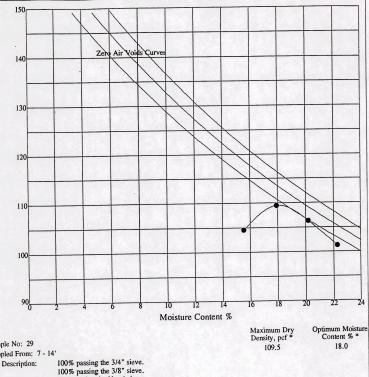
8/10/95



*Density and moisture results rounded to nearest 0.5. Method: A ASTM D 698-91 Laboratory Compaction Characteristics Job No: Plate of Soil (Proctor) рчDX-95-137 Bureau of Land Management Anita Resevior P-7 Date: Braun Intertec Corporation, Billings, Montana



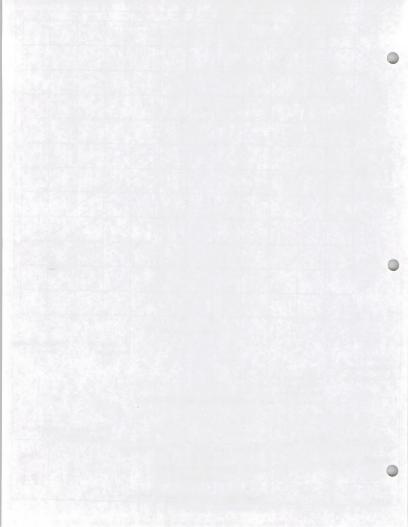
Dry Density, pcf

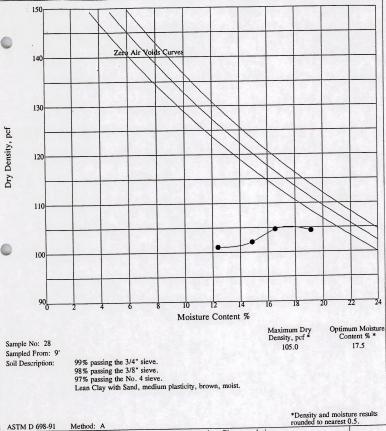


Sample No: 29 Sampled From: 7 - 14' Soil Description: 99% passing the No. 4 sieve. Lean Clay with Sand, medium plasticity, olive brown, moist.

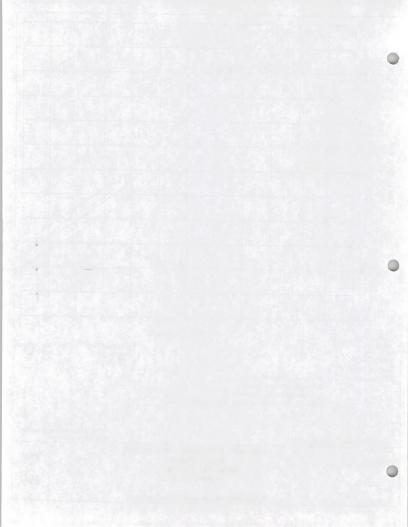
*Density and moisture results rounded to nearest 0.5. ASTM D 698-91 Method: A

Laboratory Compaction Characteristics	71
of Soil (Proctor)	Plate
Bureau of Land Management	
Anita Resevior	P-8
	1
Braun Intertec Corporation, Billings, Montana	
	of Soil (Proctor) Bureau of Land Management Anita Resevior

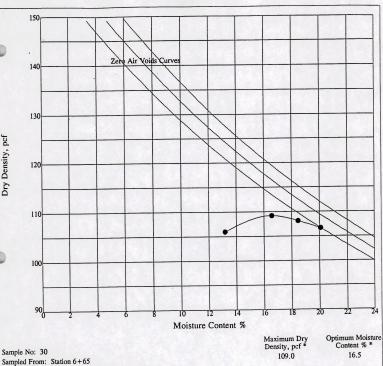




ASTM D 698-91	Method: A	*Density and moisture results rounded to nearest 0.5.
Job No: RHDX-95-137	Laboratory Compacti of Soil (P Bureau of Land	roctor)
Date:	Anita Re	P-9
8/10/95	Braun Intertec Corporation	on, Billings, Montana



Dry Density, pcf



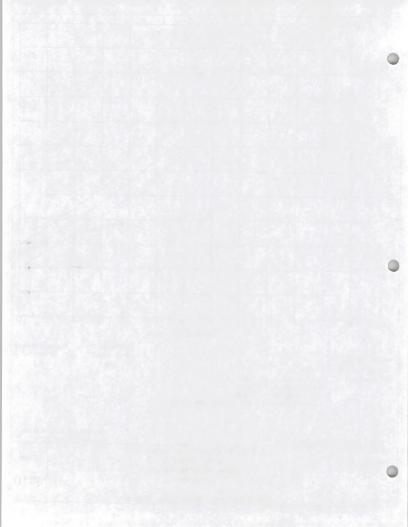
Sample No: 30

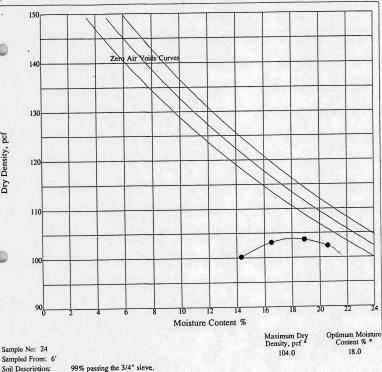
Soil Description:

100% passing the 3/4" sieve. 100% passing the 3/8" sieve.

99% passing the No. 4 sieve. Lean Clay, medium to high plasticity, olive, moist.

ASTM D 698-91	Method: A		*Density and rounded to ne	moisture results arest 0.5.
Job No: PHDX-95-137	Wedled. 71	Laboratory Compaction Characteristics of Soil (Proctor) Bureau of Land Management		Plate
Date: 8/10/95		Anita Resevior Braun Intertee Corporation, Billings, Montana		P-10





Sample No: 24 Sampled From: 6'

8/10/95

Dry Density, pcf

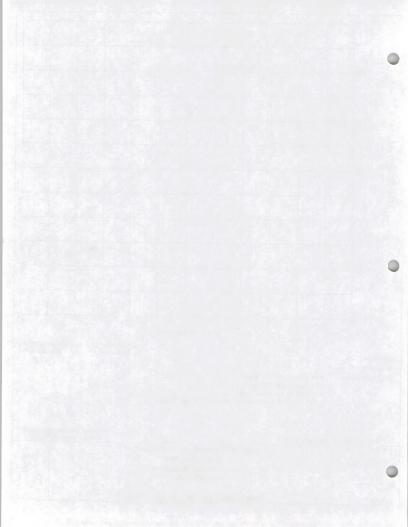
99% passing the 3/4" sieve. 99% passing the 3/8" sieve.

98% passing the No. 4 sieve.

Lean Clay with Sand, medium plasticity, brown, moist.

ASTM D 698-91	Method: A	round	*Density and moistur rounded to nearest 0.	Density and moisture results ounded to nearest 0.5.	
Job No:	Wieniod. A	Laboratory Compaction Characteristics		Diete	

of Soil (Proctor) Plate PHDX-95-137 Bureau of Land Management P-11 Anita Resevior Date: Braun Intertec Corporation, Billings, Montana





(2)

REPORT TO: BUREAU OF LAND MANAGEMENT ATTN: MR. HERB CHAVEZ

LEWISTWON DISTRICT OFFICE P.O. BOX 1160

DATE: July 25, 1996 JOB NUMBER: 96-64 SHEET 1 OF 3 P.O. NO.: 1422E060P960085

LEWISTOWN, MT 59457

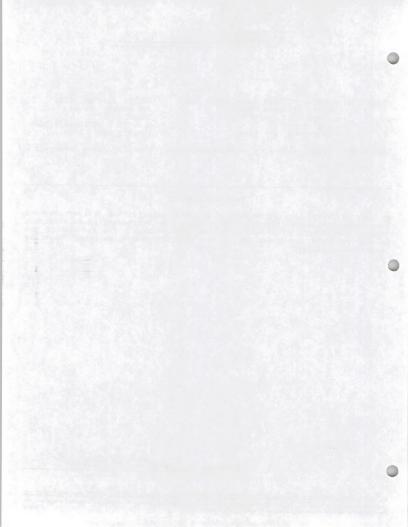
INVOICE NO.: 5918

Moisture-Density Relationship Test PROJECT: Anita Reservoir REPORT OF:

TEST DESCRIPTION

On June 24, 1996, two (2) samples of subgrade material was delivered to our laboratory. We were instructed to perform a moisture-density relationship test in accordance with AASHTO T99 on each sample. The results of the laboratory tests are presented on the attached graphs entitled "Moisture Density Relationship".

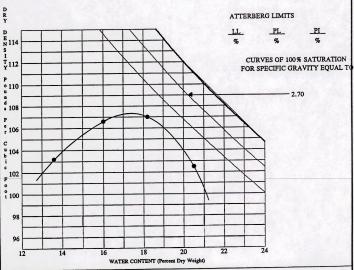
REVIEWED BY Kenneth D. Munels



Job No96-64	
Project ANITA RESE	RVOIR - BUREAU OF LAND MANAGEMENT
Source of Material BOI	RROW AREA #20 ELEV. 103
Lab No. <u>271</u>	13
Point ID and Depth	BORROW
Description of Material	LEAN CLAY (CL)
Test Method	AASHTO T99 METHOD A
Rammer Type	Manual, 5.5 #

TEST RESULTS

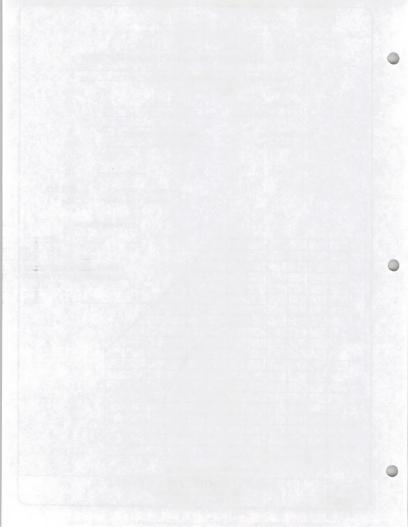
Maximum Dry Density 107.3 PCF
Optimum Water Content 17.4 %





MOISTURE-DENSITY RELATIONSHIP

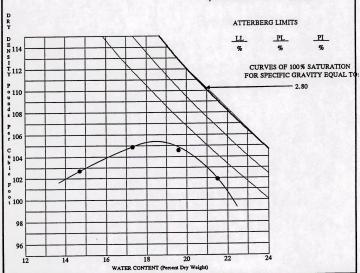
NTL Engineering & Geoscience Great Falls, Montana



41

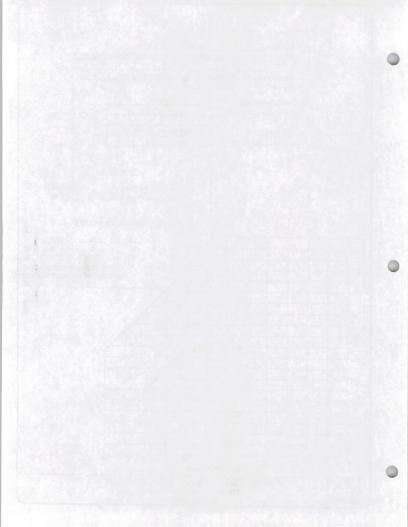
TEST RESULTS

Maximum Dry Density 105.4 PCF
Optimum Water Content 18.5 %



MOISTURE-DENSITY RELATIONSHIP

NTL Engineering & Geoscience Great Falls, Montana



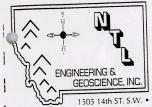
HOV 21, 96 Bel de Anglybede Epigenous disable de le Livistage, Bonian

RECEIVED

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1505 14th ST. S.W. • P.O. Box 3269 • Great Falls, MT 59403-3269 • (406) 453-5400

November 20, 1996

Bureau of Land Management Lewistown District Office P.O. Box 1160 Lewistown, Montana 59457

Attention: Mr. Herb Chavez

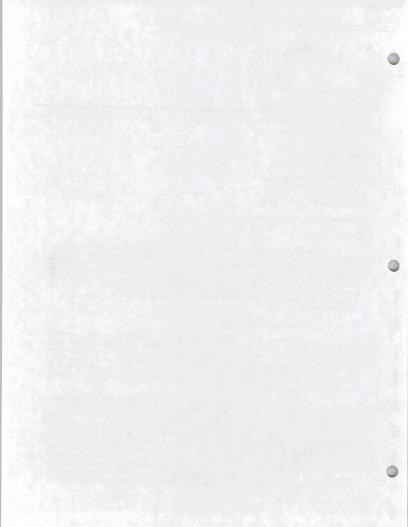
Dear Mr. Chavez:

During the week of October 7, 1996, your personnel delivered three shelby tubes from the Anita Reservoir project near Conrad, Montana. Visual classification upon extrusion of the samples found the materials to be fat clay, glacial till soils typical for the region of the continental glacier of northern Montana. Our office was instructed to perform one dimensional consolidation and unconfined compression testing in accordance with ASTM D2435 and ASTM D2166 respectively on each sample. The results of these tests are included herein, accompanied by a brief summary of testing.

Unconfined Compression

Four samples were tested for unconfined compressive strength, one from STA 6+50, STA 7+00, and two from STA 6+00. The initial test specimen from STA 6+00 had an unconfined strength of approximately 18,000 pounds per square foot (psf), while the other specimens had strengths in the range of about 6,000 to 7,000 psf. Therefore, a second specimen from STA 6+00 was tested for comparison with a resulting unconfined strength of 7500 psf. These results are presented together for comparative purposes on Plate No. 1.

All samples indicated a reasonable correlation of increasing compressive strength with increasing density and decreasing moisture content. The larger compressive strength measured for STA 6+00 may be due to the relatively high density of the fat clay specimen at a low moisture content; this sample came from the upper portion of the Shelby tube where drier conditions had apparently caused some preconsolidation or additional stiffening of the soil. The increase in moisture content of the second sample tested from the STA 6+00 tube showed a substantial reduction in unconfined strength as can be seen from the Plate No. 1. It is our recommendation that an unconfined strength value of 7500 psf be used for STA 6+00 rather than the higher value of 18,300 psf for design purposes, as the lesser value more reasonably defines the controlling unconfined compressive strength of that particular soil.



One Dimensional Consolidation

One-dimensional consolidation tests were performed on each sample. The samples were consolidated at field moisture to pressures of 4000 psf, rebounded to 1000 psf, inundated and allowed to swell under 1000 psf, reconsolidated to 4000 psf and again rebounded to 1000 psf. Compressibility of the samples was generally low, and swell magnitudes ranged from a minimal amount to as much as 2.6 percent.

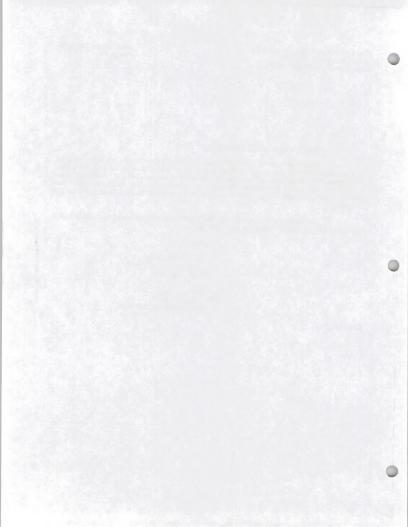
Our engineer is available for consultation regarding this data upon request. Please call if you have any questions.

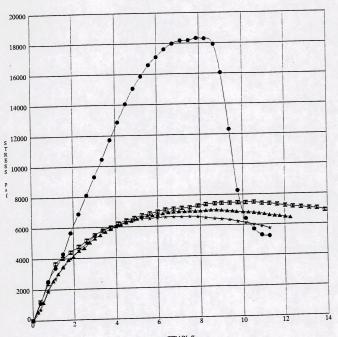
Sincerely,

Jon J. Hepfner, E.I.T. GT Staff Engineer

Gary A. Quinn, P.E. Sr. Geotechnical Engineer

JJH/GAQ/tp

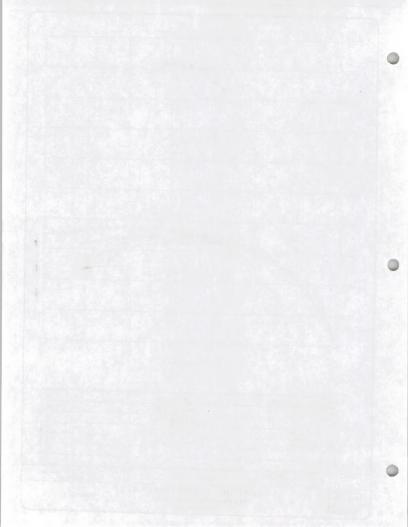


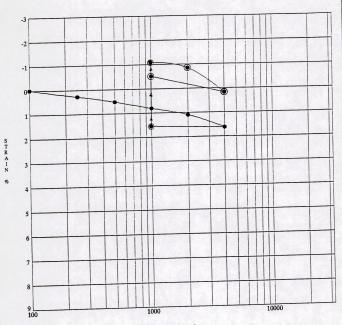


STRAIN. %

5
22
20
18
16

UNCONFINED COMPRESSION TEST NTL Engineering and Geoscience Great Falls, MT





STRESS. psf

FIELD MOISTURE

• INUNDATED

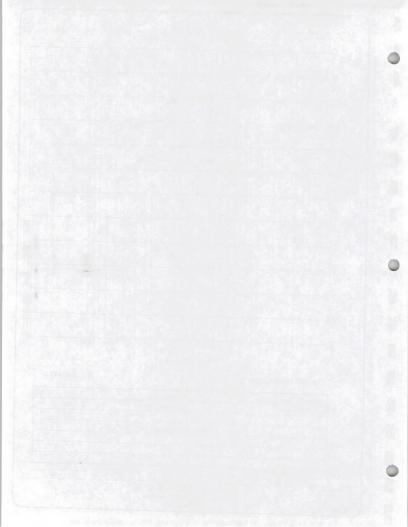
11 15 victor	Classification	DD	MC%
Specimen Identification STA 6+00 3.2	Fat Clay (CH)	109	19
	FINAL MOISTURE CONTENT =21%		
ANITA RESERVOIR Lewistown BLM	JOB NO. DATE	96-125 11/19/96	

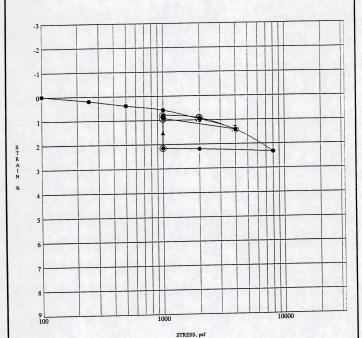


PROJE

CONSOLIDATION TEST
NTL Engineering and Geoscience

rineering and Geoscience Great Falls, MT



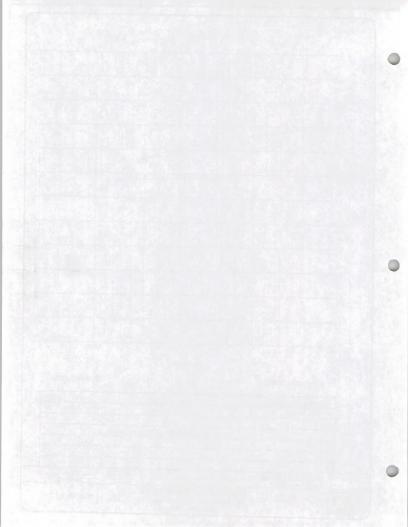


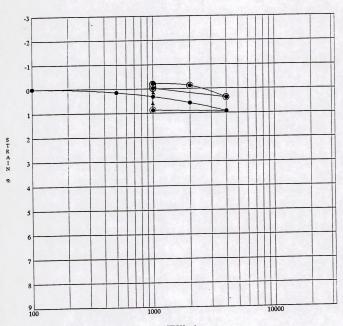
FIELD MOISTURE

INUNDATED

Specimen Identification	Classification	DD	MC%
• STA 6+50 1.1	Fat Clay (CH)	108	20
	FINAL MOISTURE CONTENT = 20%		
JECT ANITA RESERVOIR	JOB NO. DATE	96-1 11/19	

CONSOLIDATION TEST NTL Engineering and Geoscience Great Falls, MT





STRESS, psf

FIELD MOISTURE

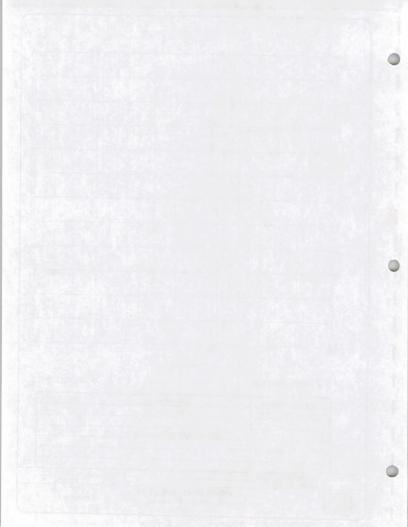
• INUNDATED

Sne	Specimen Identification		Classification	DD	MC%
	STA 7+00	2.1	Fat Clay (CH)	107	21
			FINAL MOISTURE CONTENT = 22%		
	NITA RESE		JOB NO DATE		25

*+ "Y

CONSOLIDATION TEST

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APPENDIX I

PRECONSTRUCTION MOISTURE AND DENSITY SELECTION



Method of Musture & Density Selection

AMPLE B

180 107.0 22 17.5 23 107.5 24 104.6 18.0 25 107,0 160 108.0 16.0 17.5 105.0 18.0 109.5 29 16.5 30 109.0 (ORE 118.5 10.5 132 DO NOT USE 107,0 € 17.0

20 CO NOT 151-113.0

PCF

106.5

26m

17.0

15.0

150

24

